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GUAM AGRICULTURAL EXPERIMENT STATION,
C. W. EDWARDS, Animal Husbandman in Charge,

Under the supervision of the STATES RELATIONS SERVICE,
Office of Experiment Stations, U. S. Department of Agriculture.

REPORT OF THE
GUAM AGRICULTURAL EXPERIMENT
STATION.

1917.



Issued December 16, 1918



WASHINGTON:
GOVERNMENT PRINTING OFFICE.
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GUAM AGRICULTURAL EXPERIMENT STATION, ISLAND OF GUAM.

[Under the supervision of A. C. TRUE, Director of the States Relations Service, United States Department of Agriculture.]

E. W. ALLEN, *Chief of Office of Experiment Stations.*

WALTER H. EVANS, *Chief of Division of Insular Stations, Office of Experiment Stations.*

STATION STAFF.

C. W. EDWARDS, *Animal Husbandman in Charge.*

GLEN BRIGGS, *Agronomist and Horticulturist.*

JOAQUIN GUERRERO, *Assistant in Horticulture.*

PETER NELSON, *Assistant.*

LETTER OF TRANSMITTAL.

GUAM AGRICULTURAL EXPERIMENT STATION,
Island of Guam, January 26, 1918.

SIR: I have the honor to transmit herewith a report of the Guam Agricultural Experiment Station, 1917.

Very respectfully,

C. W. EDWARDS,
Animal Husbandman in Charge.

DR. A. C. TRUE,
*Director States Relations Service,
U. S. Department of Agriculture, Washington, D. C.*

Publication recommended.

A. C. TRUE, *Director.*

Publication authorized.

D. F. HOUSTON, *Secretary of Agriculture.*

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REPORT OF THE GUAM AGRICULTURAL EXPERIMENT STATION, 1917.

REPORT OF THE ANIMAL HUSBANDMAN IN CHARGE.

By C. W. EDWARDS.

INTRODUCTION.

The work of the year was somewhat retarded by the late rainy season, and it was impossible to make any plantings of field crops previous to the middle of December. The station was also without an agronomist for five months of the fiscal period.

ANIMAL HUSBANDRY.

The animal husbandry work of the station consisted chiefly in increasing and improving the station herds, producing improved sires for upgrading the public stock, and determining the best methods of care and feeding of various classes of live stock.

On the whole the work has progressed satisfactorily during the year. There have been few deaths among the station animals, and with the exception of a few cases in the first part of the year, there has been very little evidence of the parasitic diseases which caused considerable loss among the swine and goats in 1916.

AGRONOMY.

The work in agronomy has been conducted along the same general lines as in previous years, special emphasis having been placed on forage and cover crops. Because of the possible importance of the animal industry and the great necessity for soil improvement and conservation, those crops are considered of prime importance to the welfare of the island. With these conditions in view, a large number of cover crop and forage plants have been introduced and tried at the station. Of this number velvet beans as a cover crop and Para grass (*Panicum barbinode*), *Paspalum dilatatum*, and the sorghums as forage crops have proved best adapted to the climatic and soil conditions of Guam.

HORTICULTURE.

Horticultural work has been along various lines of an experimental nature. In the second half of the year, seed and plant distribution

was an important factor in increasing the food production of the island. Much time has been devoted to vegetable gardening. Time of planting tests have shown that plantings from June 15 to October 15 are largely failures because of excessive rains and poor drainage. Fertilizer tests have been made with several of the principal vegetables to determine the kind, amount, and time of application of fertilizers. Work with fruits has received some little attention, the principal fruits with which experiments are under way being papayas, bananas, mangoes, avocados, oranges, and lemons.

INDUSTRIAL FAIR.

This station aided in inaugurating the first industrial fair, which was held in Agana just after the close of the fiscal year. This fair was a success in every particular, the general public, and especially the farmers, taking a very active interest in the event.

Besides acting on committees and serving as judges, the station staff made a very creditable exhibit of bee work, animals, and crops. Educational value was the primary consideration in the choice and arrangement of these exhibits. Improved and new food products and a better class of animals were important features emphasized by the station (Pl. I).

Not only does an educational exhibit of this kind offer an incentive toward improvement in the agricultural welfare of the island by stimulating interest, but it brings the station into closer relationship with the farmer. It is planned to make this fair an annual event.

CHANGES IN THE STAFF.

L. B. Barber resigned on August 15, 1916, being succeeded by C. W. Edwards as animal husbandman by appointment dated July 10, 1916. A. C. Hartenbower resigned his position as agronomist in charge of the station on February 13, 1917. He was succeeded by C. W. Edwards as animal husbandman in charge. Glen Briggs, formerly connected with the Oklahoma Experiment Station, was appointed agronomist of the station on March 22, 1917.

ACKNOWLEDGMENT.

During the fiscal year the most cordial relations have existed between the naval government of Guam and the station. The Governor, Capt. Roy C. Smith, is deeply interested in the agricultural development of the island and has accorded the station his most valuable support and cooperation. It is also desired to express appreciation for the valuable assistance and cooperation rendered by Lieut. E. B. Woodworth, Chief, Department of Industries, and his assistant, Mr. R. C. Gibson.

ANIMAL HUSBANDRY.

The following executive order issued by the Governor of Guam on November 14, 1916, and modified December 12, 1916, should assist very materially in the general live-stock improvement work, as the average rancher gives very little if any attention to the practice of selection:

NAVAL GOVERNMENT OF GUAM,
GOVERNMENT HOUSE, GUAM,
November 14, 1916.

EXECUTIVE SPECIAL

ORDER No. 39.

1. On and after July 1, 1917, an annual tax of \$5, United States currency, per head will be levied on all bulls between the ages of six months and eight years. Bulls registered in accordance with paragraph 2, and steers will not be subject to this taxation.

2. Bulls for breeding purposes must be registered. A limited number of selected bulls will be registered after an inspection by the superintendent of industry, or by such persons as he may designate.

3. The Government will castrate, without charge, all bulls that are brought to Agana, and the superintendent of industry or his representative will make periodical trips to the various parts of the island for the same purpose and for the purpose of instructing the cattle owners in the proper method of castration.

4. A fine of \$15, United States currency, will be imposed on anyone castrating bulls by other than approved methods. The custom of crushing the testicles between stones, etc., is very harmful to the animals, often resulting in death, and must be discontinued.

5. All laws and parts of laws inconsistent herewith are hereby repealed.

ROY C. SMITH,
Governor of Guam.

DECEMBER 12, 1916.

EXECUTIVE SPECIAL

ORDER No. 40.

1. Executive Special Order No. 39 of November 14, 1916, is modified as follows:

Change paragraph 1 to read as follows:

"On and after July 1, 1917, an annual tax of \$5, United States currency, per head will be levied on all bulls between the ages of one year and eight years. Bulls registered in accordance with paragraph 2 and steers will not be subject to this taxation."

2. The minimum age of bulls subject to taxation has been increased to one year, although it is far better to castrate the bulls before they reach the age of six months. The United States Government has for years kept experts in other tropical countries, especially in the Philippine Islands, for the purpose of studying cattle. These experts have gathered information that shows that bulls should be castrated before they reach the age of six months. This applies to cattle that are to be used for work as well as for food. A bull that is castrated before he is six months old will grow to be a stronger and better animal for work than one that is castrated at the age of two years.

ROY C. SMITH,
Governor of Guam.

In the animal-husbandry work of the station, aside from the breeding experiments, considerable attention is being given the study of feeds and feeding methods. Owing to the high cost of imported feeds, this subject is one of special importance in the development of the live-stock industry of Guam.

The station has proved that a sufficient supply of suitable green forage can be easily produced locally. There is little doubt that satisfactory grain rations for all classes of stock could be compounded from the grains which it is possible to produce locally. The great difficulty in the work of determining these rations lies in the fact that at present none of these grains except corn are produced in any quantity. Even the latter can be secured in sufficient quantities only during the harvest periods. This condition is due mainly to the difficulty of keeping grain in storage from one season to another.

HORSES.

The increase in the number of horses was limited to one male colt, William Cassius, out of Princess by Cassius. No further attempt was made to enlarge the stud, as it is considered that the present number of breeding stock is all that the station can advisably maintain under prevailing conditions.

Only a few privately owned native mares were bred to the station sires. There are only a small number of native ponies on the island. Very little use is made of these ponies and it is difficult to get the owners to bring the mares to the station for service. An improved type of pony could be used to good advantage on most ranches. A plan is being considered whereby these native mares, a majority of which are now ranging in isolated districts, will be brought in and kept at the station until bred.

FEEDING TESTS.

The test begun September 1 of last year, in which the feeding values of Para grass and alfalfa hay were being compared, was continued until March 15 of the present year. On November 1 two more horses were included in the test. The horses were either used at light work or given daily exercise during the period.

Throughout the experiment the weights of the animals were maintained or only slightly increased by the Para ration, while the alfalfa gave a considerable increase of weight in each instance. The total of results would seem to indicate that Para grass can be satisfactorily utilized as the entire forage portion of the maintenance or light work ration of horses. With respect to gains in weight, results were much in favor of the alfalfa hay. The Para grass, however, constituted much the cheaper feed. Oats constituted the grain ration throughout the period.



FIG. 1.—STATION GRADE GOATS.



FIG. 2.—PORTION OF CATTLE EXHIBIT.

SOME EXHIBITS AT THE GUAM INDUSTRIAL FAIR.



FIG. 1.—THREE-QUARTER-BLOOD AYRSHIRE-NATIVE CALF SIX MONTHS OLD; WEIGHT, 245 POUNDS.

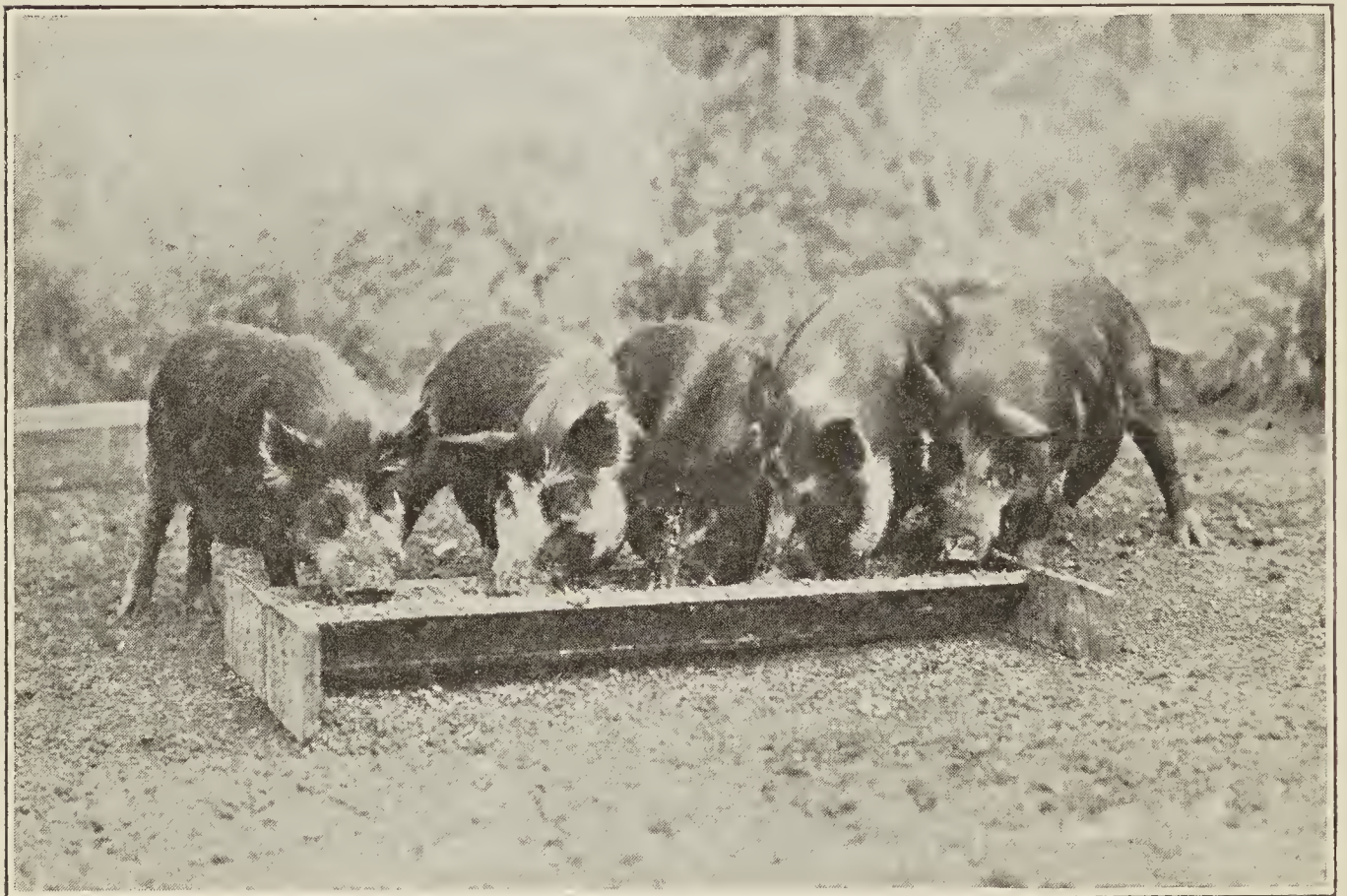


FIG. 2.—HALF-BLOOD BERKSHIRE-NATIVE SOWS.

In a test extending over a period of three months in which six horses were used, copra meal was substituted for one-half (by weight) of the grain ration of oats. The cost of the meal was considerably less than that of the oats and no loss of weight or other ill effects followed the use of the ration in question.

CATTLE.

With the exception of a short illness of each of the two Ayrshire bulls, the station herds remained in good health throughout the year. The pure-bred Ayrshires were maintained in good flesh on cut Para grass and Paspalum pasture, and a very light grain ration. This was particularly true of those which had been raised on the island. The two cows, Red Rose and Guam Rose, as was the case the previous year, failed to get with calf although having been bred several times during the year. Aside from the possible exception of one bull while stationed at Cotot, the pure-bred cattle have shown no abnormal temperatures or other ill effects of tick infestation. At the Piti station the biweekly use of the arsenical dip has been sufficient to keep the animals free of ticks.

The Cotot grade and native herd remained in good condition with the exception of a few old native cows which were kept on native pastures during the dry season.

The Ayrshire bull Harry Gray was transferred to Cotot on March 17. Near the close of the year he died, the illness causing his death, lasting only a few days. The symptoms of this case were similar to those exhibited by the bull upon previous occasions of his transfer to this station. About the same time the Ayrshire bull John Gray, maintained at Piti, showed an illness characterized by a slight weakness in the hind quarters. At the close of the year the ailment did not appear to be serious.

The only losses among the herds were two calves at the Cotot station. The increase numbered one three-quarter blood Ayrshire (Pl. II, fig. 1) and nine half-blood Ayrshires. The former shows the red and white color markings and the general conformation of the pure-blood Ayrshire. A majority of the half-bloods show the general lines of the Ayrshire and mixed color markings, either white and black or white and red, instead of the usual solid color of the native cattle.

In regard to the public breeding work, one half-blood Ayrshire-native bull was stationed for free service at the Agana corral until April 6. On this date the animal was transferred to a ranch near Agana, where he was given free range with a herd of about 75 native cows. Two other bulls of the same breeding remained in the same location as in the previous year, one ranging with a good sized herd in the district of Merizo and the other with a smaller herd in the Agat

district. These bulls, although receiving no extra care or feed other than the native pasture, remained in as good condition as any of the native cattle with which they were running, a fact indicating the comparative hardiness of the half blood. Aside from these grade bulls, two pure-blood Ayrshire bulls have been available for free public service at the Piti station.

Only a few cows have been brought to the regular stations for service. The experience of the past few years in connection with the public cattle upgrading work indicates that much more can be accomplished through the practice of placing sires out in the various districts than by the plan of allowing the owners to bring their cows to the station for service.

A pasture experiment was begun on February 14 at the Cotot stock farm, the object being to determine the comparative value of Para grass and native pastures. Seven native cows and one 2-year-old grade heifer (No. 38) were used in the test.

The following table shows the results obtained up to the close of the fiscal period:

Comparative value of Para grass and native pastures.

Lot No. 1 Para pasture				Lot No. 2, native pasture.			
Cow No.	Weight, Feb. 14.	Weight, June 29.	Gain in weight.	Cow No.	Weight, Feb. 14	Weight, June 29.	Loss in weight.
	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>		<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>
20.....	432	520	88	12.....	569	437	132
30.....	497	551	54	17.....	510	366	144
31.....	359	485	126	18.....	624	519	105
38.....	324	462	138	26.....	620	579	41

In connection with this experiment it should be noted that the test was conducted during the dry season and that native cow No. 31 and heifer No. 38 were in very poor flesh at the time they were turned on the Para.

This experiment will be continued. As soon as larger pasture areas and better weighing facilities are provided at Cotot, it is planned to carry on more extensive experiments of this nature.

Experiments have been carried on for the past two years comparing the normal temperatures of two imported and three Guam-bred Ayrshire cattle and the temperatures of two tick-infested and two tick-free native cows. In the latter case the cows were reversed at the close of the first year, that is, the two tick-infested cows of the first year were the tick-free ones the following year. There was found to be practically no difference between the daily temperature of the imported and Guam-bred Ayrshires or between the tick-infested and tick-free native cattle.

SWINE.

At the beginning of the year the swine herd consisted of 2 pure-blood and 2 half-blood Berkshire boars, 1 native and 11 half-blood sows (Pl. II, fig. 2), and 17 half-blood and three-quarter-blood pigs.

During the year, crossing the grade sows with the pure-bred sires was continued in an effort to establish a station breeding herd and to produce stock for public use in upgrading the native swine of the island. The increase during the year consisted of 10 half-blood and 43 three-quarter-blood pigs. Five grade boars and 9 grade sows were sold to individuals for breeding. One half-blood boar was loaned for public use for a part of the year, during which time 40 sows were bred to him. Eleven native sows, the property of farmers living in the vicinity of the station, were bred to the pure-blood station sires.

In September, 1 grade sow and 1 grade boar were transferred to Cotot. It is intended to maintain a small herd at this station with which to carry on feeding experiments.

During the early part of the year a few cases of lard and lung worms were encountered. Pasture rotation, frequent disinfection of breeding pens and runs, and the sale for slaughter of unthrifty stock were practiced. During the latter half of the year there were no deaths from these pests.

PASTURE TESTS.

On January 16, a test was begun to compare the value of native and Para grasses as pastures for young, growing pigs. Twelve three-quarter-blood pigs (10 sows and 2 barrows) of approximately the same age (3 months) were divided into two as nearly equal lots as possible. Lot No. 1 was placed on an area of approximately $\frac{1}{2}$ acre of native pasture and lot No. 2 on an area of approximately $\frac{1}{4}$ acre of Para grass. Each lot received equal amounts of the same grain ration.

The following table shows the results obtained at the close of a 90-day period:

Comparative value of Para grass and native pastures.

Lot No. 1, native pasture.				Lot No. 2, Para pasture.			
Pig No.	Weight, Jan. 16.	Weight, Apr. 16.	Gain in weight.	Pig No.	Weight, Jan. 16.	Weight, Apr. 16.	Gain in weight.
	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>		<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>
120.....	18.5	45	26.5	123.....	25.5	75	49.5
122.....	32.5	77.5	45	125.....	19.5	65.5	46
124.....	21	49	28	127.....	21	55.5	34.5
128.....	17	38	21	138.....	27	66	39
134.....	17	39.5	22.5	139.....	19	54.5	35.5
141.....	18	51	33	140.....	14	55.5	41.5
Total.....	124.0	300.0	176.0	Total.....	126.0	372.0	246.0
Average.....	20.6	50.0	29.3	Average.....	21.0	62.0	41.0

From the above it will be noted that the pigs having access to the Para grass pasture made a total average gain of 11.7 pounds more than the lot running on native pasture. The plot of Para grass in this case was a planting of about two years' standing. As the experiment was conducted in the dry season when the grass made very little growth, the returns were probably not so favorable as would be obtained from a pasture containing more new growth.

BREADFRUIT AND COCONUTS AS SUBSTITUTES FOR A PORTION OF THE GRAIN RATION.

On May 1 a test was begun in order to obtain data indicating to what extent cooked breadfruit and grated coconut may be used as substitutes for a portion of a mixed grain ration. Twelve three-quarter-blood pigs (10 sows and 2 barrows) of about 7 months of age were used in this experiment. These were divided into two lots each containing 5 sows and 1 barrow, there being a difference of only 2 pounds in the total weights of the lots. Lot No. 1 was given daily 15 pounds of a grain mixture composed of equal parts of ground oats and ground rough rice, and 10 per cent by weight of cowpea meal. The daily ration of lot No. 2 consisted of 7.5 pounds of the above mixture, together with 12 pounds of cooked breadfruit and 4 pounds of grated coconut. Both lots were pastured on Para grass.

At the close of the fiscal year, or 60 days after the test was started, lot No. 1 showed a considerable gain in weight over lot No. 2. However, this was due largely to the small gains made by one individual in lot No. 2. Soon after the end of the year the condition of this pig was such that it was necessary to withdraw the animal from the test. With the elimination of this pig, there was very little difference in the average gain made by the two lots.

This experiment will be continued and reported in detail in the next annual report.

CHICKENS.

The chickens have been entirely free from contagious diseases. This condition has been maintained in spite of the fact that serious outbreaks of chicken pox and cholera have occurred among the native chickens in the vicinity of the station. The results of the year have been satisfactory, except that many of the pens of growing chicks showed a marked unevenness in development and that the percentage of hatch, especially during the latter part of the season, was low.

A number of eggs for setting and some young breeding stock were sold to the public, and a few pure-bred cocks were loaned to some of the more interested poultry raisers. The experimental work has been confined chiefly to incubation, brooding, and feeding tests with chicks.

Pullet-laying flocks of pure-bred Brown Leghorns, Brown Leghorn native No. 5 hybrids, and Rhode Island Red No. 11 hybrids were maintained and production records kept of each individual in order to permit the selection of next year's breeding pens. At the beginning of the year all the stock of the No. 12 cross was disposed of, as it was evident that with the facilities available it would be impossible properly to continue all the lines of cross-breeding work that had been started. The No. 12 cross, referred to in previous reports, was considered the least promising of the hybrids.

BROODING EXPERIMENTS.

Efficiency of artificially heated brooders.—Two tests of the efficiency of artificially heated brooders were conducted, in the first of which 94 chicks of the No. 11 cross were removed from the incubator 36 hours after hatching and divided into two equal lots. Lot No. 1 was placed on the brooder-house floor with a Cyphers kerosene brooder. Lot No. 2 was placed on the brooder-house floor in a compartment of the same size as that for lot No. 1 but without the brooder. For the first three days both lots were fed chick feed No. 1 (3 parts bread crumbs and 1 part hardboiled egg) four times daily. After the third day both lots received once daily chick feed No. 1 and twice daily chick feed No. 2 (a mixture of wheat, corn, oats, and cowpeas, finely ground, with a small amount of grit and charcoal). Green feed was also given. The temperature of the brooder was kept at 90° F. The second test was a duplication of the first except that in this case each lot of chicks consisted of 42 No. 11 and 10 No. 5 cross-bred chicks. Both tests were run for 42 days during the months of December and January—the cool season or at least the period of cool nights.

The following table gives a summary of the results of the two tests:

Efficiency of artificially heated brooder.

System of brooding.	Number of chicks.	Number of deaths.	Average weight per chick at 42 days.
Kerosene brooder.....	99	10	Ounces. 6.3
Brooder-house floor without brooder.....	99	16	4.2

It will be noted that the kerosene brooder gave the best results both as to mortality and weight of chicks. These results would seem to indicate the advisability of using, during the cool season at least, the artificially heated brooder rather than rearing the chicks in brooder house without a brooder.

Comparison of artificially heated and fireless brooders.—Fireless brooders were made from waste box lumber and patterned after that described by Purvis,¹ except that the covering of the hover, lining of box, and front curtain were made of burlap instead of flannel and no packing was put between the lining and sides of the box.

Duplicate tests were conducted, each including two lots of chicks of 20 No. 5 hybrids and 30 Brown Leghorns. Lots No. 1 were placed on the brooder-house floor with kerosene brooder, and lots No. 2 in a like compartment with the fireless brooder. The feed of each lot consisted of chick feed No. 1, fed four times daily for the first five days, following which the chicks had access to trays containing chick feed No. 2, with chick feed No. 1, fed twice daily. A summary of the results of these tests follows:

Comparative value of artificially heated and fireless brooders.

System of brooding.	Number of chicks.	Number of deaths.	Average weight per chick at 42 days.
Kerosene brooder.....	100	8	Ounces. 6.0
Fireless brooder.....	100	12	6.8

These tests were conducted after February 15, or during the warm season. The results indicate that during this period of the year and under the conditions stated artificial heat is not necessary in the process of brooding.

Comparison of Hawaiian,² kerosene, and fireless brooders.—A test was run for 42 days during the hot season with three lots of chicks, each consisting of 20 No. 5 hybrids and 30 Brown Leghorns. Lot No. 1 was placed in a compartment of the brooder-house floor with the kerosene brooder, lot No. 2 in a like compartment with the fireless brooder, and lot No. 3 in the Hawaiian brooder. One pound of chick feed No. 2 was spread evenly over the floor of the Hawaiian brooder and covered with about 3½ inches of light rice. The feed of each lot for the first five days consisted of chick feed No. 1 fed four times daily. Following this period lots Nos. 1 and 2 had access to trays containing chick feed No. 2, while all lots were given chick feed No. 1 twice daily. After the first three days lots Nos. 1 and 2 had access to ground runs.

¹ Purvis, M. Poultry Breeding, Chicago, 1912, p. 82.

² The brooder referred to as the "Hawaiian," a home-made box brooder described in Guam Sta. Rpt. 1916, p. 55, was given this name because the plans were furnished by the Hawaii Agricultural Experiment Station.

The following tabulation shows the results obtained in this test:

Comparative value of Hawaiian, kerosene, and fireless brooders.

System of brooding.	Number of chicks.	Number of deaths.	Average weight per chick at 42 days.
			<i>Ounces.</i>
Kerosene brooder.....	50	5	8.0
Fireless brooder.....	50	7	7.6
Hawaiian brooder.....	50	14	6.8

There was no appreciable difference in the results obtained with the kerosene brooder and with the fireless brooder, but the Hawaiian brooder was less satisfactory both as to the average weight of the chicks reared and the percentage of mortality. The majority of deaths in this case were due to crop impaction caused by the chicks' eating the light rice which contained grain. This could perhaps be overcome by the use of hulls in the place of the light rice.

No ill effects were experienced from the practice of allowing the chicks of lots Nos. 1 and 2 to run outdoors, as was the case two years previous. Later about 200 chicks were raised by this method with a comparatively low mortality.

INCUBATION TESTS.

The Cyphers incubator is the only machine possessed by this station. The incubation experiments included age of egg, moisture, and temperature tests. The incubation facilities and number of eggs of any one variety produced precluded extensive experimental work in this direction.

A comparatively low percentage of hatch was secured throughout the season. From December 1 until February 28, the average hatch did not exceed 50 per cent, and following this date the hatchability gradually dropped until the last hatch, completed in April, did not exceed 20 per cent. In general the low percentage of hatchability may have been due to the fact that the flock contained some old hens, some inbred stock, and also that at certain stages of the hybrid-breeding work the percentage of infertility is liable to be high. This does not explain, however, the decrease in hatchability of eggs during the later season. In all hatches where the incubator was run at a temperature from 102° to 103° F. the hatch was complete on the twentieth day.

Age of egg and moisture test.—For hatch No. 1, all eggs were date-marked and saved from 1 to 14 days (December 25 to January 8, inclusive).¹ The hatch was set on January 8 at 4 p. m. The incubator was run at 102° to 103° F., and the concrete floor under the machine was sprinkled twice daily throughout the period of incu-

¹ No eggs were set from the last day's gathering.

bation. The method of procedure for hatch No. 2 was the same as for hatch No. 1, except that no moisture was added to the floor under the incubator. The results of this test are shown in the following table:

Effect of added moisture and age of eggs on hatchability.

HATCH NO. 1 (ADDED MOISTURE).

Age of eggs.	Num- ber of eggs set.	Number of eggs infertile.	Percent- age of infer- tility.	Number of eggs fertile.	Percent- age of fertility.	Number of eggs with dead germ.	Percent- age of fertile eggs with dead germ. ¹	Number of eggs hatched.	Percent- age of hatcha- bility. ¹
<i>DAYS.</i>									
14.....	13	10	76	3	24	2	66	1	34
13.....	17	11	64	6	36	6	100	0	0
12.....	18	9	50	9	50	8	88	1	12
11.....	21	5	23	16	77	14	87	2	13
10.....	20	2	10	18	90	14	77	4	23
9.....	19	2	10	17	99	15	88	2	12
8.....	13	2	15	11	85	3	27	8	73
7.....	28	4	14	24	86	12	59	12	50
6.....	21	1	4	20	96	5	25	15	75
5.....	24	1	4	23	96	9	39	14	61
4.....	28	1	3	27	97	11	40	16	60
3.....	26	1	3	25	97	3	12	22	88
2.....	21	1	4	20	96	4	20	16	80
Total..	269	50	18.5	219	81.5	106	48.4	113	51.6

HATCH NO. 2 (NO MOISTURE ADDED).

14.....	26	20	76	6	24	6	100	0	0
13.....	26	19	73	7	27	6	85	1	15
12.....	27	15	55	12	45	12	100	0	0
11.....	26	11	52	15	48	14	93	1	7
10.....	24	7	29	17	71	13	76	4	24
9.....	29	5	17	24	83	19	79	5	21
8.....	19	3	15	16	85	5	32	11	68
7.....	21	2	9	19	91	9	47	10	53
6.....	22	4	18	18	82	9	50	9	50
5.....	21	3	14	18	86	5	27	13	73
4.....	12	0	0	12	100	2	16	10	84
3.....	13	1	7	12	93	3	25	9	75
2.....	14	3	21	11	79	1	9	10	91
Total..	280	93	33.2	187	66.8	104	55.6	83	44.4

¹ Percentage of dead germs and chicks hatched based on fertile eggs and not on the total number of eggs et.

Eggs from the same pens or varieties of fowls were used in the case of each hatch, but as the number of eggs of each variety was not the same in both cases close comparisons in regard to the moisture test are impossible. However, the summary of results throughout the season would seem to indicate that during the dry season at least the percentage of hatch was slightly increased by the addition of moisture.

These tests, together with those performed in previous years, point strongly to the fact that under ordinary circumstances eggs for hatching should not be kept for a longer period than 10 days at the most.

GOATS.

The disease situation which proved so serious last year improved rapidly until during the latter part of the present year there was no



FIG. 1.—PARA GRASS PLATS IN FERTILIZER TEST.



FIG. 2.—FORAGE PLATS; SUDAN GRASS ON LEFT, JACK BEANS AND VELVET BEANS ON RIGHT.

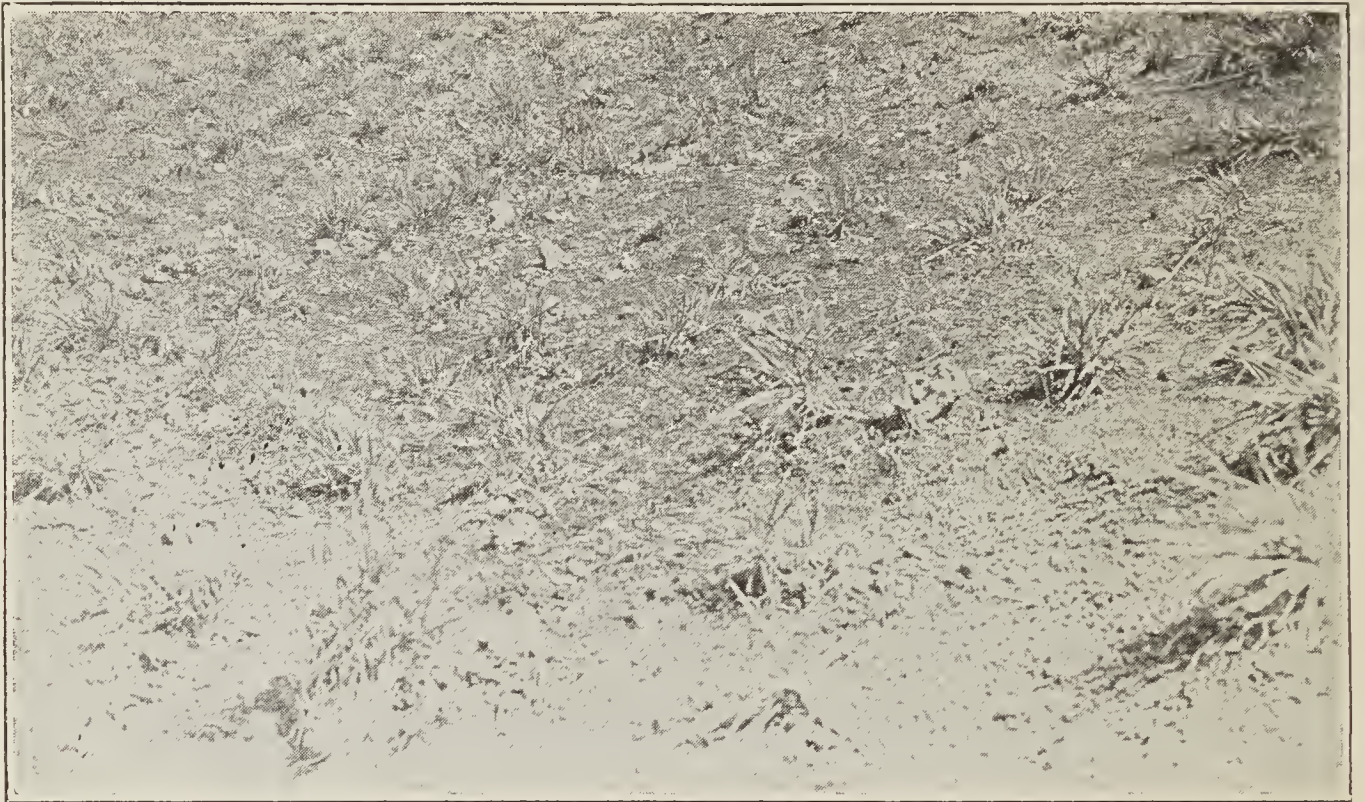


FIG. 1.—PASPALUM GRASS SIX MONTHS AFTER PLANTING, SHOWING EFFECT OF EARLY PASTURING.



FIG. 2.—PASPALUM GRASS SIX MONTHS AFTER PLANTING, NOT PASTURED.

evidence of either the nodular or the stomach worms and at the close of the period the herd was apparently in good condition. The total of deaths numbered 10 head, the greatest loss being the death from liver fluke of the remaining pure-bred Toggenburg buck.

Eighty does were bred to the three grade bucks loaned for public breeding. All the kids except one sired by the Toggenburg buck showed the typical color markings of the sire, with size and conformation superior to the native stock.

REPORT OF THE AGRONOMIST AND HORTICULTURIST.

By GLEN BRIGGS.

AGRONOMY.

GRASSES AND FORAGE PLANTS.

Para grass (Panicum barbinode).—As stated in last year's report, an experiment was started July 1, 1915, to determine the effect of fertilizers and cultivation on an area of Para grass that had been planted sometime previous and was well established at the time the test was begun (Pl. III, fig. 1). The following table gives a summary of the results up to June 30:

Effect of different treatments for renovating Para grass.

Plat No.	Area of plats.	Treatment per acre.	Acre yield of green forage.
	<i>Acre.</i>		<i>Pounds.</i>
1	0.41	Sodium nitrate, 704.2 pounds; acid phosphate, 951.2 pounds; potassium sulphate, 460.9 pounds.....	116,080
2	.41	No treatment.....	55,458
3	.23	Sodium nitrate, 351.2 pounds; acid phosphate, 414.6 pounds; potassium sulphate, 195.1 pounds; plowed.....	55,160
4	.23	Plowed.....	42,395
5	.24	Sodium nitrate, 538 pounds; acid phosphate 554.2 pounds; potassium sulphate, 260.8 pounds.....	61,508
6	.24	No treatment.....	41,504
7	.21	Manure, 15 tons; plowed.....	104,423
8	.21	Manure, 15 tons.....	132,257

It will be noted that plat No. 8, to which only manure had been applied, gave the heaviest yield, indicating that, of the fertilizers used in the test, manure is the most efficient for renovating Para grass. Plat No. 1, treated with a heavy application of a complete commercial fertilizer, gave the next highest yield, followed by plat No. 7, which had been both plowed and manured. The lowest yield was from plat No 6, a check plat which had received no treatment.

The amount of the fertilizer elements applied to the two highest yielding plats is shown in the following table. Common barnyard manure was used, the analysis given being an average employed in

the United States.¹ The analysis of the commercial fertilizer represents the minimum figures furnished by the company from whom the fertilizers were purchased.

Comparison of fertilizer elements used on Para grass.

Plat No.	Treatment.	Amount of fertilizer elements applied per acre.					
		Nitrogen (N).		Phosphorus (P ₂ O ₅).		Potash (K ₂ O).	
8 1	Manure.....	Pounds.	Per cent.	Pounds.	Per cent.	Pounds.	Per cent.
	Commercial fertilizer.....	150 105.6	0.5 15	45 133.1	0.15 14	120 193	0.4 42

Para grass is a good soiling crop, which may also be pastured with profit if judiciously handled. As resting the pasture at certain intervals throughout the year is imperative, an area large enough to permit pasture rotation should be planted. Para grass has been put in at this station in several of the lowland pastures where it succeeds better than on the upland.

Paspalum dilatatum.—During the last dry season, this grass again demonstrated its superiority over other improved grasses in withstanding drought and heavy pasture, especially on the hillsides. It remained green and succulent all summer on a steep cascajo hillside, although it did not grow vigorously until light rains began in June and July. It is primarily a pasture grass, but one apparently adapted to many types of soil. Besides the cascajo hillsides, *Paspalum* has also been planted on the lowlands and uplands and is doing well in all these locations.

In order to secure the best results, a sufficient time must be allowed for *Paspalum* to establish itself before it is pastured. Goats were turned into a side-hill field about three months after planting *Paspalum*, and within two months they had eaten the grass down to the roots, leaving a nearly bare area. The grass quickly recovered at the beginning of the rainy season. Plate IV, figure 1 shows the field six months after planting, when it began to recover from the effects of early pasturing, while figure 2 shows a fenced portion of the same planting which had not been pastured, both areas having received the same treatment except for the pasturing. The field shown in Plate IV, figure 2 is well established and ready for heavy pasturing, while that shown in figure 1 will require the whole rainy season in which to recover, with extra labor to keep the weeds down until the grass is well started again. Neither *Paspalum* nor Para grass should be pastured when very young, but *Paspalum* will stand much heavier pasturing at that time than will Para grass.

¹ Hopkins, C. G. Soil Fertility and Permanent Agriculture, Boston, 1910, p. 157.

Plantings have been made to find the best distance between plants and the most suitable size of root division to use in propagating *Paspalum*. The distances tried, with both small and large root divisions, have been 12, 18, 24, 30, 36, and 60 inches. Plantings 12 inches each way with sods cut into 2-inch squares have given the best results on the several types of soil.

The station continues to distribute large quantities of Para grass and *Paspalum* for planting. Aside from the regular pastures and experimental plants, an area is kept in sod sufficient to furnish all requests for root divisions and cuttings.

Sudan grass (Andropogon sorghum).—The first successful introduction of Sudan grass into Guam was made by this station during the year. The first crop, produced during the dry season, was harvested 108 days after planting and yielded 9.83 tons to the acre of first-class forage. At the close of the year, although during the dry season, the crop was making a good growth, assuring a good second cutting. The forage seemed to be relished by cattle and horses and from first trial results it bids fair to become another valuable soiling crop for Guam. Plate III, figure 2, shows the first crop when it was heading out.

Sorghums.—Early Black Amber cane and some of the grain sorghums tested here have given promising results, especially as soiling crops to supplement Para grass and *Paspalum* during the dry season.

Two fields planted to Amber cane in January, 1917, yielded 8 and 8.5 tons, respectively, of forage per acre at the first cutting, and 5.92 and 10.4 tons at the second cutting. One field was so badly damaged by kernel smut (*Sphacelotheca sorghi*) that it was plowed and planted to velvet beans. The other was not infested and is now producing a third crop (second ratoon crop), and comparative data will be secured from the successive ratoon crops as to size of stalks, quality, yield, and feeding value of each.

Black-hulled White kafir and some of the other grain sorghums have proved profitable crops during the dry season. Black-hulled White kafir seems to be especially suitable for Guam, as it furnishes forage at a time when the pastures are short, and also supplies a much-needed grain for feed. During the year kafir yielded 10.5 tons of forage at the first cutting and 31.65 bushels of thrashed grain per acre, the highest yield yet reported on the island. The first ratoon crop made 7.98 tons of forage.

Judging from the available data for the grain sorghums, there is evidently a direct correlation between season or time of planting and the yield and number of days to mature. During the wet season, the grain sorghums mature in less time, but the yield is very materially reduced, while in the dry season, during which time crops blossom

and set grain, opposite results are secured in the absence of heavy rains. The data on this subject given in the following table cover only seven scattering tests, and for that reason are not conclusive:

Effect of date of planting on maturity and yield of grain sorghums.

Date of planting.	Kafir.				Feterita.				Milo.			
	Grain.		Forage.		Grain.		Forage.		Grain.		Forage.	
	Number of days to mature.	Yield.	Number of days to mature.	Yield.	Number of days to mature.	Yield.	Number of days to mature.	Yield.	Number of days to mature.	Yield.	Number of days to mature.	Yield.
July 16, 1915:		Bu.		Tons.		Bu.		Tons.		Bu.		Tons.
First crop.....		(1)	91	6.25		(1)	91	11.35				
Ratoon crop.....	156	10.8	156	2.3		(1)	60	9.59				
Nov. 20, 1915.....	111	13.2			92	11.4			92	9.3		
Dec. 1, 1915.....	115	9.1			96	7.8			96	6.8		
Jan. 8, 1916.....	103	23.5	103	3.99	100	18.18	100	4.0	93	15.7	93	2.81
Apr. 19, 1916.....		(1)		(2)								
Jan. 27, 1917.....	114	31.6	114	10.5								

¹ No grain formed in head, doubtless due to rainy weather at heading time.
² Forage very poor; not cut.

CORN (ZEA MAYS).

Corn breeding work.—As noted in former annual reports corn improvement work was begun with a native white variety in 1915. The object of this work was the production of a variety possessing early maturing qualities, one ear to the stalk, and uniformity of ear and stalk, with later increase of yield and improvement in quality if possible. This work has been continued and during the last year the fourth and fifth generations matured.

The first crop was satisfactory in nearly every particular. It matured in 102 days, several days earlier than the ordinary native corn, and made an average yield of 37 bushels per acre, practically a 50 per cent increase over the native corn production, which rarely reaches 25 bushels per acre. This increase, however, may not all be due to selection, as the corn received better cultivation than is commonly given it by the native farmer.

The fifth generation was very nearly a failure, a result due to several causes. The seed, planted January 9, 1917, had to be replanted on January 19, and even after replanting, the stand was so thin that small seedlings had to be transplanted from some rows to fill other rows of the same selection, the vacant rows being again replanted. Yet with all this attention a poor stand was secured which was further injured by an attack of a borer, probably the larva of a species of *Diatræa*. The work of this borer was checked by spraying with a solution of 4 pounds lead arsenate to 100 gallons water. A large number of barren stalks was noticeable in the crop, but

whether this was due to the severe drought or to heredity could not be determined, as no data had previously been recorded relative to that particular point, which, however, will be more fully investigated in the succeeding crops. There also appeared a mixture of yellow corn in this generation, undoubtedly from cross pollination of the year previous, as no other corn was planted anywhere near the field this year. Mention was made in last year's notes of a variety of yellow corn not producing ears, but evidently it produced pollen and cross-pollinated the white corn. Because of all the above circumstances, seed selection from any one row was impossible, and selection from the whole fifth generation was difficult, as the ears had to be taken from the several rows with pedigrees tracing back to former selections showing good performance records.

Corn notes.—Although corn is the most universally cultivated crop on the island, forming a large part of the food eaten by the Chamorro people and being to them what wheat is to the Americans, they have manifested no interest in its improvement until the last few years. Some of the more progressive ranchers living near the station and the insular government farms are beginning to use more improved methods of cultivation. Their work is serving as a visual demonstration to other ranchers of the value of more and better cultivation to increase yields. The average native thinks he has cultivated sufficiently, if, after plowing, he chops a hole in the ground and drops in the seed and then cuts out the weeds with a fosiño once or twice during the growth of the crop. Field selection of seed is not generally practiced.

During the past year the station staff, in cooperation with Mr. R. C. Gibson, of the department of industries, insular government, visited certain fields and made selections, later distributing these to interested farmers. It is hoped that by this method the farmers will be brought to see the benefit derivable from planting better seed and will put the knowledge into practice. This, however, will require further demonstrations and much time and patience, as the Chamorro is very slow to adopt new customs.

TOBACCO (NICOTIANA TABACUM).

Work similar to that carried out last year with six imported varieties of tobacco had been planned, but the seed failing to germinate, a native variety was substituted in order that the fertilizer, shading, and insect enemy studies might be continued. The plats used in the experiment are the same as those used in last year's work, being 12 by 100 feet with rows 3 feet apart. Those numbered 2, 4, and 6 were fertilized at the rate of 320 pounds of nitrate of soda, 320 pounds of acid phosphate, and 120 pounds of sulphate of potash per acre. The treated plats were sprinkled once a week with a mixture

of 7 parts corn meal and 1 part lead arsenate. The results are given in the following table:

Summary of results of fertilizer, shading, and insect-control experiments with tobacco.

Plat No.	Treatment.	Number of plants.	Total number of leaves.	Number of leaves per plant.	Total weight of leaves.	Total weight of stalks.	Weight of leaves per plant.
					<i>Ounces.</i>	<i>Ounces.</i>	<i>Ounces.</i>
1a	Shaded, untreated.....	29	1,404	48.4	452	628	15.6
2a	Shaded, untreated, fertilized.....	28	673	24.0	240	280	8.5
1b	Unshaded, untreated.....	34	1,521	44.7	476	778	14.0
2b	Unshaded, untreated, fertilized.....	34	1,612	47.4	432	1,000	12.7
1c	Unshaded, treated.....	32	1,882	58.8	664	1,116	20.7
2c	Unshaded, treated, fertilized.....	34	1,692	49.8	540	988	15.9
1d	Shaded, treated.....	31	1,267	40.8	492	656	15.8
2d	Shaded, treated, fertilized.....	29	787	27.1	332	428	11.4
3a	Shaded, untreated.....	28	529	18.9	224	220	8.0
4a	Shaded, untreated, fertilized.....	23	546	23.7	168	184	7.3
3b	Unshaded, untreated.....	31	1,262	40.7	400	664	12.9
4b	Unshaded, untreated, fertilized.....	22	789	35.8	232	696	10.5
3c	Unshaded, treated.....	31	1,225	39.5	520	764	16.8
4c	Unshaded, treated, fertilized.....	23	1,174	51.0	460	812	20.0
3d	Shaded, treated.....	25	642	25.7	264	272	10.5
4d	Shaded, treated, fertilized.....	24	659	27.4	240	232	10.0
5a	Treated.....	51	1,637	32.1	444	984	8.7
6a	Treated, fertilized.....	38	1,175	30.9	472	808	12.4
5b	Untreated.....	43	1,369	31.8	448	864	10.4
6b	Untreated, fertilized.....	50	1,543	30.8	568	972	11.3

The results of the fertilizer tests of 1916 and 1917 are rather contradictory, the unfertilized plats giving 274 pounds of leaves, the fertilized plats only 230 $\frac{1}{4}$ pounds. No reason can be assigned for this difference, as the plats were uniform and were treated as in the previous year.

In the shading tests, the data showed that the shaded plats gave only 88.7 per cent as many first and second grade leaves as did the unshaded plats. The unshaded plats treated with lead arsenate gave the largest number of leaves, the largest number of entire leaves of first and second grade, and the highest total number of pounds of tobacco.

The results of the two years' experiments indicate strongly that insect control is the most important factor in the raising of marketable tobacco. They have also proved that shading tobacco is detrimental as well as unprofitable and that treating with lead arsenate is beneficial in securing a larger yield, as well as a better grade of tobacco. The two years' work with fertilizers are so conflicting that it will be necessary to continue the experiment until more conclusive data can be secured.

The insects on the tobacco were identified by the Philippine Bureau of Agriculture as a species of gryllid and *Chloridea* (*Heliothis*) *assulta*. The latter insect was reported last year as *H. obsoleta*.

COTTON (GOSSYPIUM SPP.).

Yield data.—Plants of all the cotton varieties from the planting made on June 22, 1915, were cut back for ratoon crops on April 11,

1916. Pickings were made on August 2, 12, and 27. The yields are shown below:

	Pounds per acre.
Cook's Improved.....	525
Covington-Toole.....	630
Triumph.....	570
Blue Ribbon.....	450
Hartsville.....	840

The fiber was weak and low grade. All of the plants were removed from the field after the last picking, as fully two-thirds were dead. The plantings made December 7, 1915, were pruned heavily on May 8, 1916 (the Egyptian variety on June 7), to determine the value of a ratoon crop from each variety. The data from this ratoon crop are summarized as follows:

Yields of seed cotton from first ratoon crop of planting of Dec. 7, 1915.

Type.	Variety.	Dates of picking.	Yield per acre.
			Pounds.
Upland.....	Covington-Toole..	Aug. 2, 12, 27; Nov. 8....	825
Do.....	Columbia.....	do.....	877
Do.....	Hartsville.....	do.....	1,148
Egyptian.....	Gila.....	.....	.....

The Egyptian cotton failed to make a ratoon crop. The quality of the cotton from all plats was inferior both in length and grade of fiber. The long time between the third and fourth pickings was probably due to heavy rains, which are detrimental to the production of bolls.

The following table gives a comparison of first crop and subsequent ratoon crop yields as far as can be determined from the station records:

Comparison of yields of seed cotton from first crops and subsequent ratoon crops.

Type.	Variety.	Date of plant- ing.	Yield per acre.		
			First crop.	First ratoon crop.	Second ratoon crop.
			Pounds.	Pounds.	Pounds.
Upland.....	Covington-Toole..	1914.....	¹ 1,770	1,012	357
Do.....	Columbia.....	do.....	¹ 588	1,137	524
Egyptian.....	Gila.....	do.....	¹ 1,024	301	None.
Upland.....	Cook's Improved..	June 22, 1915	1,478	525	(²)
Do.....	Covington-Toole..	do.....	1,423	630	(²)
Do.....	Triumph.....	do.....	1,382	570	(²)
Do.....	Blue Ribbon.....	do.....	1,067	450	(²)
Do.....	Hartsville.....	do.....	1,820	840	(²)
Do.....	Covington-Toole..	Dec. 7, 1915	1,479	825	(²)
Do.....	Columbia.....	do.....	1,287	877	(²)
Do.....	Hartsville.....	do.....	1,754	1,148	(²)
Egyptian.....	Gila.....	do.....	571	None.	(²)
Do.....	Hawaiian.....	Jan. 26, 1917	922	(³)	(³)
Do.....	Arizona.....	do.....	873	(³)	(³)
Do.....	Guam.....	do.....	823	(³)	(³)
Upland.....	Hartsville.....	do.....	974	(³)	(³)
Do.....	Covington-Toole..	do.....	788	(³)	(³)

¹ These yields are supposed to be those of the first crop, but this is not definitely known as the records are not clear.
² Died.
³ Not producing yet.

From the results already obtained it appears that the upland varieties are more likely to produce a ratoon crop than are the Egyptian varieties, and that cotton plants generally die before or soon after being cut back for a second ratoon crop. Only the growth of one season made a second ratoon crop.

Variety work.—Cotton investigational work was carried on with five varieties during the year, of which three were of the Egyptian type grown in Hawaii, Arizona, and at this station and two were of station-grown upland. Test plats were planted January 26, 1917, from which only two pickings have been secured. Results are summarized below:

Results of cotton variety test.

Type and variety.	Stand.	Yield of seed cotton per acre.	Average linting.	Average length of lint.	Number of bolls per pound of seed cotton.	Weight of 100 seeds.
	<i>Per cent.</i>	<i>Pounds.</i>	<i>Per cent.</i>	<i>Inches.</i>		<i>Grams.</i>
Egyptian:						
Hawaiian.....	95	921.8	32.2	1 ³ / ₁₆	140.8	13
Arizona.....	90	872.6	32.5	1 ⁵ / ₃₂	128.8	10.2
Guam.....	65	823.4	31.4	3 ¹ / ₂	78.3	10.9
Upland:						
Hartsville.....	50	974.4	32.5	1	64.8	13.6
Covington-Toole.....	45	787.6	36.0	1 ³ / ₈	82.8	10.3
Native (wild).....			25.4	1 ⁴ / ₈	155.9	26.9

The drag was poor in all cases but all exhibited a most remarkable strength of fiber. Considering the stand, Hartsville gave the best results, although the Egyptians made a good showing in length of lint. Covington-Toole is much on the type of the so-called “half-and-half” variety and will probably never be raised in Guam unless a longer lint can be produced by selection and breeding. As soon as the rains started, the cotton stopped producing, but the stalks continued to look healthy and vigorous.

As mentioned in the 1916 report, steps were taken toward providing ginning facilities on the island, but these were unsuccessful and the same conditions still obtain, that is, a company stands ready to provide a gin when there is sufficient cotton produced to make it pay and the farmers will not attempt to raise the cotton so long as there is no ready market for their product. As the farmers have not enough capital to buy a gin of their own, the problem can be solved in one of two ways, either by the farmers organizing and producing enough cotton to warrant the installation of a gin by the company in question or some other firm or by the organization of an outside company with sufficient capital to cooperate with the farmers, provide seed, and see that a sufficient acreage is planted and given proper care to supply the gin, the company guaranteeing a suitable market for all cotton produced and delivered to their gin. It is very doubtful whether the Chamorro farmer, without one of the above incentives,

will ever take the initiative and produce a crop, especially one requiring as much labor as that necessary to produce satisfactory yields of cotton.

According to the station records, considerable seed was distributed last year to farmers making requests. It has later developed, however, that much of the seed was never planted.

A few good grade fishing nets are made from cotton, which is ginned by hand. Thread is made from the lint with the use of a small spindle about 6 inches long, which hangs down at the end of the thread and is twirled between the spinner's fingers, a method more primitive than the use of the spinning wheel. As this is a very tedious as well as slow process, most of the twine for making nets is imported. With small modern machinery a fair-sized industry could be started that would probably pay, as fishing nets are much in demand and imported ones are costly.

Cotton work will be continued, not with the expectation of starting a commercial enterprise within the near future, but for the purpose of obtaining experimental data relative to cotton in the Tropics which may be used in making proper suggestions as to varieties and methods of management in case market conditions become favorable.

RICE (ORYZA SATIVA).

Rice work was a failure during the past fiscal year because of insufficient moisture and high winds from the northwest which blasted the crop at blossoming time. Variety and fertilizer experiments were started similar to those carried on during the last fiscal year, and these will be continued next year, as the work is considered important because of the fact that rice makes up a large part of the native diet. During the two years data taken in regard to the cost of producing an acre of rice have yielded the following results:

Cost of producing an acre of rice.

Preparation of land-----	\$10.00
Planting -----	6.50
Cultivation -----	3.00
Harvesting and thrashing-----	3.00
<hr/>	
Total -----	22.50

In some places on the island, attempts at rice growing have failed, while in some other instances small yields have been obtained. This is especially the case on land that has been cropped to rice continuously from 10 to 40 years. Efforts will be made to improve these conditions by the use of better seed and better cultivation and by the addition of fertilizers if these are found necessary.

Rotation of crops can not be recommended indiscriminately, because of the small amount of land adapted to the growing of rice,

the necessity of building permanent dikes and ditches, the lack of modern machinery for preparing the land and harvesting the crop, and the scarcity of animals for use with the modern machinery.

Green manure and cover crops offer a possibility of improving the soil provided varieties of legumes can be grown which can be turned under with the native plow. These plows are all small and will not ordinarily turn under a very luxuriant growth, but as the paddies are flooded when plowed, it may be possible under these conditions to turn under a green manure crop.

COVER CROPS.

Cover crops are evidently very much needed in Guam, as the seasons vary from extremely dry to extremely wet periods. During the dry season they reduce evaporation from the soil, while during the wet season, when the ground can not be cultivated to any great extent, they prevent erosion and keep down weeds.

Three years ago, very little attention was given to cover crops in Guam, but now they are recognized as being especially valuable in connection with successful soil management problems. Their feeding value as forage or their use as soiling crops in Guam has not been thoroughly tested, but no doubt they will prove as valuable on the island as in the Southern States. Suitable cover crops for the climatic seasons have not been definitely determined, but especially favorable results have been obtained with velvet beans and jack beans.

Jack beans, velvet beans, and cowpeas, in a planting made February 28, 1917, were used as cover crops in the citrus orchard. During the dry season they were most effective in the order named, but soon after the rains commenced (in June) the velvet beans quickly took first place, with the jack beans second, while the cowpeas died after producing a small crop of peas during May. The cowpeas did not cover the ground, but the jack beans, although more upright, were also more bushy and shaded the ground better, keeping down most of the weeds except the wild morning-glory, which was held in check only by the velvet beans.

In a variety test of the Mauritius velvet bean and the jack bean, both completely covered the ground and have been fruiting for the last six months (Pl. III, fig. 2). The yields so far recorded are 277 pounds hulled seed per acre for the velvet beans and 925 pounds for the jack beans. The velvet beans did not bear heavily because they had no supports, most of the seed rotting where they came in contact with the ground.

Velvet beans, planted on a steep cascajo hillside in February, after standing a severe drought, had by the first of June covered the ground

between 4-foot rows, forming a heavy growth which will prevent erosion during the rainy season.

Yields of velvet beans have been from 0 to 14.3 bushels per acre of seed and as high as 7.3 tons of green forage. They mature in 116 to 178 days but will remain on the ground for a period of several months. There is one area on the station grounds that has been in velvet beans for two years, and the growth is still covering the ground. They not only cover the ground more completely than the jack bean but have a less woody vine. The disadvantage of using them is that they will climb upon and cover other crops with which they are planted, necessitating at times the removal of the vines from the other crop.

The jack bean matures earlier than the velvet bean and shades the ground fairly well, although it does not spread. The principal objection to the jack bean is its woody growth which makes the plant difficult to work into the soil after its use as a cover crop is ended.

The black-eyed cowpea matures in about 80 days, but the yield of peas is small and the growth of vine insufficient to cover the ground. After fruiting, it dies and does not produce a second crop.

Pigeon peas were planted in double rows on March 23, 1917, around the citrus and papaya orchards. In three months they had grown to a height of 6 feet, and during the coming rainy season they will no doubt make a quick growth, providing an effective windbreak during the season of high winds. The peas planted around the garden tract and mentioned in last year's annual report have grown 12 to 14 feet in height and have produced a large crop of seed as well as making a very efficient windbreak.

A test was started in the latter part of the year to determine the best cover crop for papayas. Velvet beans, jack beans, pigeon peas, mung beans, and cowpeas were used in the test. Data are not yet available relative to this experiment.

GREEN MANURING.

Green manuring has not been practiced in Guam, possibly because of the natives' lack of agricultural knowledge and their primitive methods of tilling the soil. The farmers until recently have used wooden plows, but are now fast adopting a small, one-handled steel plow. Neither plow, however, is capable of turning under as rank a growth as that of a green manure or a cover crop. The soil lacks organic matter, and green manure is the only available means of supplying it. The native has no barnyard manure to apply to his land, as the stabling of animals is not practiced.

It will be necessary for the native farmer to change his method of cultivation before he can utilize green manure crops to any great extent, but definite agricultural progress depends on the use of crops

of this nature. For this reason experiments with varieties of green manuring plants and tests of different cultural methods are considered of no little importance.

ALFALFA.

As negative results were secured last year in tests of alfalfa on the lowlands of the station, three tests of the crop were started this year on hillsides with different slopes and different soil textures. One test plat planted in January grew very little during the dry season, but after a clipping with the mower, it made a good growth with the beginning of the rains. After the heavy rains had continued for sometime, the alfalfa on this plat began to die, although in apparently one of the best drained locations at the station. The plants of the other tests were still alive at the end of the fiscal year but were too young to determine how they would stand the climatic conditions. All uninoculated plats were much slower in growth than the inoculated plats.

WEED ERADICATION WITH ARSENICALS.

Weed eradication experiments were continued with arsenic sprays, as described in last year's report. The sprays, while effective on the plants above ground, did not kill the roots, which produced plants again after the first rain. Under local conditions the use of arsenic sprays in this work was found to be more expensive and less effective than hand labor.

SOILS.

Very little experimental work has been done with soils by the station because of the small staff and the lack of laboratory facilities. A few litmus and hydrochloric acid tests were made on soils with material secured from the naval hospital. The station soil in most cases showed the presence of carbonates, but two samples gave acid reactions. More of these simple field tests will be made as soon as material is available to make them. Several representative soil samples have been submitted to the Bureau of Soils, United States Department of Agriculture, for chemical and mechanical analysis. Results have only been reported on samples taken near the north end of the island. The soil there is very shallow and lies in a district that is not well watered. The samples represent three depths; No. 1, surface soil, or soil from 1 to 6 inches deep; No. 2, subsurface soil, or soil from 7 to 12 inches deep; and No. 3, subsoil, or soil from 13 to 18 inches deep. The mechanical analysis is given in the table following.

Mechanical analysis of soil from the north end of the island.

Kind of soil.	Sample No. 1.	Sample No. 2.	Sample No. 3.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Fine gravel (2 to 1 mm.).....	3.9	1.1	0.5
Coarse sand (1 to 0.5 mm.).....	19.2	8.0	8.9
Medium sand (0.5 to 0.25 mm.).....	9.4	6.5	6.8
Fine sand (0.25 to 0.1 mm.).....	25.5	31.6	32.1
Very fine sand (0.1 to 0.05 mm.).....	9.4	22.1	20.0
Silt (0.05 to 0.005 mm.).....	18.9	18.4	20.6
Clay (0.005 to 0 mm.).....	14.1	12.5	11.1

The chemical analysis of the same soil is given below. Milton Whitney, Chief of the Bureau of Soils, United States Department of Agriculture, says of these samples:

These soils are in several respects the most peculiar chemically that we have encountered in our laboratory. We would draw your attention to the extremely low silica content and to the high content of iron and alumina, and the relatively high content of phosphoric acid. Soils of somewhat similar characteristics in composition, although not so extreme, are found in Hawaii.

Chemical analysis of soil from the north end of the island.

	Sample No. 1.	Sample No. 2.	Sample No. 3.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Silica (SiO ₂).....	1.08	0.99	0.88
Titanium (TiO ₂).....	2.02	2.09	2.12
Iron (Fe ₂ O ₃).....	18.65	21.31	21.00
Alumina (Al ₂ O ₃).....	38.35	41.26	41.71
Manganese (MnO).....	.37	.31	.24
Lime (CaO).....	2.09	1.40	3.84
Magnesia (MgO).....	.10	.13	.08
Potash (K ₂ O).....	.13	.12	.11
Soda (Na ₂ O).....	.42	.40	.39
Phosphoric acid (P ₂ O ₅).....	1.84	1.94	1.75
Sulphuric acid (SO ₃).....	.63	.42	.51
Nitrogen (N).....	.82	.38	.28
Loss on ignition (excluding nitrogen).....	33.60	28.66	27.76

Pot experiments are being planned for the next fiscal year, with the view of making a preliminary study of several soil types common on the island. A number of fertilizer tests are under way, but no results other than those already reported are available at the present time.

HORTICULTURE.

The work in horticulture during the past year was conducted along various lines, but special emphasis was placed on seed and plant distribution, vegetable gardening, and fruit growing.

SEED AND PLANT DISTRIBUTION.

The distribution of seeds and plants continues to be an important factor in the work of the station. The demand among the native farmers for plant material increased very perceptibly, especially

during the latter part of the year. This has been due largely to the activities of the local government in inducing the people to take steps toward increasing the food production of the island. The station is putting forth every effort to assist in this work. The increase in the number of inquiries relative to seeds and methods of planting indicates a growing interest in these matters on the part of the native farmer.

A considerable increase over former years is shown in the distribution of plants and seeds. Many of the farmers have also saved their own seeds due to encouragement in that direction and advice from the station. The following is a list of plants, rooted cuttings, and seeds that have been distributed during the past year:

Plants, rooted cuttings, and seeds distributed.

	Number.		Number.
Papaya (<i>Carica papaya</i>).....plants..	2,097	Pineapples (<i>Ananas sativa</i>).....plants..	162
Hibiscus (<i>H. rosa-sinensis</i>).....do....	5,699	<i>Bougainvillea spectabilis</i>.....do....	3
<i>Barleria cristata</i>.....do....	34,305	Royal pa'm (<i>Oreodora regia</i>).....do....	25
Caballero (<i>Cesulpinia pulcherima</i>) do....	1,850	Miscellaneous.....do....	451
Dama de noche (<i>Cestrum nocturnum</i>),		Vegetable seeds.....packages..	7,182
plants.....	2,508	Bermuda grass roots.....sacks..	17
<i>Tabernaemontana grandiflora</i>....plants..	212	Para grass (<i>Panicum barbinode</i>) roots,	
Crêpe myrtle (<i>Lagerstrœmia indica</i>) do....	2,140	sacks.....	75
<i>Albizia lebbek</i>.....do....	845	<i>Paspalum dilatatum</i> roots.....sacks..	159
<i>Carissa grandiflora</i>.....do....	250	Velvet beans.....pounds..	37
<i>Allamanda neriifolia</i>.....do....	36	Jack beans.....do....	8
Avocado (<i>Persea gratissima</i>).....do....	17	Florida beans.....do....	14
Bay tree (<i>Pimenta acris</i>).....do....	27	Pigeon peas (<i>Cajanus indicus</i>).....do....	5
Banana (<i>Musa sapientum</i>).....do....	47	Upland rice.....do....	5
Taro (<i>Caladium colocasia</i>).....do....	16	Sudan grass seed.....do....	1½

This makes a total distributed to various parts of the island of 50,690 plants, 7,182 packages of vegetable seed, 251 sacks of grass roots, 59 pounds of leguminous plant seed for cover crops, and a large number of kafir heads that were not recorded.

PLANT INTRODUCTIONS.

Plant introductions during the past year have been limited, because of the rigid restrictions placed on introductions into the island in order to keep out dangerous pests and diseases.

During the first part of the year two shipments of seed were received from the island of Madagascar. These were introduced under local names, but only the following have grown: Tulipier du Gabon, Grenadille, Olil de Paon, Kapokier, Lilas de Senegal, Giroflier, and Papaya.

Other important introductions made during the fiscal period are Sudan and Rhodes grass from the Bureau of Plant Industry, United States Department of Agriculture; mung beans and chico seeds from the Bureau of Agriculture, Philippine Government; cotton and papaya seeds from the Hawaii Station; oats from Sweden; several

ornamental plants and palms secured by purchase; and the following from the Office of Foreign Seed and Plant Introduction. Bureau of Plant Industry, United States Department of Agriculture: *Pimenta acris*, *Amygdalus communis*, *Litchi chinensis*, *Swietenia mahagoni*, *Annona cherimola*, *A. squamosa*, *Ficus benjamina*, *Adenanthera pavonina*, *Enterolobium cyclocarpum*, *Macadamia ternifolia*, *Melastoma molkenboerii*, *Synechanthus* sp., *Acrocomia sclerocarpa*, and *Seaforthia elegans*.

VEGETABLE GARDENING.

Most of the common vegetables grow to a greater or less extent during the whole year. With this fact in mind, plantings have been made every month, and more frequently when possible, in order to find the best time of planting for yield as well as quality. In the tests that have been made it was found that the plantings made from June 15 to October 15 were more or less failures due to excessive rains and poor drainage. Cucumbers proved to be an exception and yielded a large crop during the rainy season. The station garden is located on a low, heavy clay soil that is retentive of water. This is probably the cause in part of the large percentage of failures during the rainy season. A large portion of the lowland area of the island, however, is of this type of soil.

Other experiments that are being conducted include variety tests, a comparison of Guam-grown and imported seed, and effects of fertilizers and time of application. Toward the end of the coming year it is expected that there will be sufficient garden data from which to draw definite conclusions, which data it is planned to present as a separate bulletin.

Tests of Guam-grown seed *v.* imported seed indicate that imported seed are the better, but nothing beyond the first generation has been tested. More work should be carried on to find whether successive generations would be more successful.

The general effects of fertilizers have been increased production, better quality of vegetables, and in some cases greater resistance to insects, or at least an increase in ability to overcome or recover from their ravages. The same fertilizer plans as given in last year's report were followed and will again be used during the coming year.

Where not otherwise specified, the fertilized plats have been treated with a complete fertilizer consisting of 85 pounds nitrogen, 149 pounds phosphoric acid, and 200 pounds potash per ton. This was applied broadcast at the rate of 1,000 pounds per acre, and then worked well into the soil previous to planting the seed.

Experiments have also been conducted with different kinds, amounts, and time of application of fertilizers to Lima beans, string beans, radishes, carrots, peppers, cucumbers, and eggplants.

Beans.—The following table shows the results of a fertilizer test with Henderson Bush Lima and Kentucky Wonder beans. These varieties have proved in numerous trials to be particularly well adapted to local conditions. From this test it can readily be seen that fertilizers materially increased the yield and that a complete fertilizer applied before planting gave the highest production.

Results of 1917 fertilizer tests with beans.

Plat No.	Fertilizer per acre.	Yield per acre.	
		Hender-son Bush Lima.	Ken-tucky Wonder.
		<i>Pounds.</i>	<i>Pounds.</i>
1	No fertilizer.....	2,317.8	168.3
2	Nitrate of soda, 250 pounds.....	3,468.8	785.5
3	Acid phosphate, 625 pounds.....	3,212.5	1,218.8
4	Potassium sulphate, 270 pounds.....	3,182.2	1,937.5
5	Nitrate of soda, 250 pounds; acid phosphate, 625 pounds.....	3,443.8	3,031.3
6	No fertilizer.....	2,106.2	2,118.8
7	Nitrate of soda, 250 pounds; potassium sulphate, 270 pounds.....	3,400.0	2,125.0
8	Acid phosphate, 625 pounds; potassium sulphate, 270 pounds.....	3,250.0	3,143.8
9	Nitrate of soda, 250 pounds; acid phosphate, 625 pounds; potassium sulphate, 270 pounds.....	3,531.2	5,306.6
10	Nitrate of soda, 250 pounds; acid phosphate, 625 pounds; potassium sulphate, 270 pounds; one-half applied before planting and one-half one week later.....	3,387.5	3,950.0

Carrots.—This crop did not respond to fertilizers so readily as other vegetables. In the only test of the year there was too much variance in results to indicate the best fertilizer or combination of fertilizers. This experiment and all other fertilizer tests will be continued until conclusive data can be secured.

Cucumbers.—More or less trouble is experienced at all times of the year with a fungus attacking cucumber vines. Bordeaux mixture has been used but has not been successful in combating the disease. Two crops have been harvested in an experiment to determine the effect of fertilizers and of Bordeaux spray in combination with fertilizers. The results are given in the following table:

Effect of fertilizers and Bordeaux spray on cucumbers.

Plat No.	Treatment per acre.	Yield per acre.		
		First test.	Second test.	Average.
1	Manure, 3,000 pounds; nitrate of soda, 928 pounds; acid phosphate, 1,856 pounds; potassium sulphate, 464 pounds.....	<i>Dozen.</i> 1,081.4	<i>Dozen.</i> 927.6	<i>Dozen.</i> 1,004.5
2	Manure, 3,000 pounds; acid phosphate, 1,856 pounds; potassium sulphate, 464 pounds.....	1,454.5	4,557.6	3,006.0
3	Manure, 3,000 pounds.....	2,422.5	6,639.8	4,531.1
4	No treatment.....	1,008.3	1,794.8	1,401.5
5	Manure, 3,000 pounds; nitrate of soda, 928 pounds; potassium sulphate, 464 pounds.....	1,895.6	670.4	1,183.0
6	Manure, 3,000 pounds; nitrate of soda, 928 pounds; acid phosphate, 1,856 pounds.....	3,909.7	1,149.4	2,529.5

Effect of fertilizers and Bordeaux spray on cucumbers—Continued.

Plat No.	Treatment per acre.	Yield per acre.		
		First test.	Second test.	Average.
7	Manure, 3,000 pounds; nitrate of soda, 464 pounds; acid phosphate, 928 pounds; potassium sulphate, 232 pounds.....	<i>Dozen.</i> 1,608.2	<i>Dozen.</i> 408.3	<i>Dozen.</i> 1,008.2
8	Manure, 3,000 pounds; nitrate of soda, 464 pounds; acid phosphate, 928 pounds; potassium sulphate 232 pounds; sprayed once weekly with Bordeaux mixture.....	98.2	473.8	286.0
9	Manure, 3,000 pounds; nitrate of soda, 464 pounds; acid phosphate, 928 pounds; potassium sulphate, 232 pounds; sprayed twice weekly with Bordeaux mixture.....	178.9	201.6	190.2
10	Manure, 3,000 pounds; nitrate of soda, 464 pounds; acid phosphate, 928 pounds; potassium sulphate, 232 pounds; sprayed three times weekly with Bordeaux mixture.....	398.2	428.5	413.3
11	Manure, 3,000 pounds; nitrate of soda, 464 pounds; acid phosphate, 928 pounds; potassium sulphate, 232 pounds.....	829.2	1,048.6	988.9
12	Manure, 3,000 pounds; nitrate of soda, 464 pounds; acid phosphate, 928 pounds; potassium sulphate, 232 pounds.....	1,023.3	735.9	879.6

Plats 6 and 12 were better drained in the first test, a fact which probably accounts for such large yields from them, as it was very wet during part of the test. Yields were not so heavy on the plats treated with Bordeaux spray as on the untreated ones, while the plat treated with barnyard manure alone gave the highest production.

Peppers.—Peppers are produced in Guam the whole year round. All varieties from the small native chili pepper to the large bell type do exceptionally well. Shading during the dry season with coconut leaves placed on frames has greatly increased the size, quality, and yield of peppers in all of several tests. Shading experiments have been carried on for some time with the regular fertilized and unfertilized plats. The results of the last two years' work are given in the table below. Test No. 1 of each year was planted in January and test No. 2 in March.

Effect of fertilizers and shading on peppers.

Test No.	Treatment.	1916			1917		
		Yield per acre.		Average number of pods per pound.	Yield per acre.		Average number of pods per pound.
		Number of pods.	Weight.		Number of pods.	Weight.	
1	Fertilized, shaded.....	67,000	<i>Pounds.</i> 8,550	7.8	131,600	<i>Pounds.</i> 13,100	10
	Fertilized, unshaded.....	37,600	3,000	12.5	70,200	3,800	17.9
	Fertilized, shaded.....	18,800	2,350	8	32,400	5,000	4.5
12	Fertilized, unshaded.....	3,300	350	9.4	10,000	950	10.5
	Unfertilized, shaded.....	5,600	700	8.	14,800	1,300	11.4
	Unfertilized, unshaded.....	1,600	150	10.6	7,800	600	13

¹ After July 26 the shaded plats gave no yield, while the unshaded plats yielded as follows: Fertilized and unshaded, 53,400 peppers, weighing 4,550 pounds; unfertilized and unshaded, 28,200 peppers, weighing 2,150 pounds.

The size of the peppers grown on the shaded and unshaded plats can readily be compared from the column giving the average number of peppers required to make a pound. From test No. 2 of 1917, it would appear that shading also helps to hasten the crop, thus producing a larger crop in a much shorter period of time. The combination of fertilizer with shade gave yields nearly two to six times those of the unshaded, untreated plats.

In a special fertilizer test started during the year, one crop has been harvested. The plants were transplanted from flats on August 10, 1916; the first harvest was made on November 3, 1916, and the last on June 6, 1917, or 300 days after being transplanted. During the last part of the year the yield was probably reduced by the extremely dry weather. The table below is a summary of the results of the fertilizer combination test.

Fertilizer test with peppers.

Plat No.	Fertilizer treatment per acre.	Yield per acre.	
		Number of pods.	Weight.
1	Nitrate of soda, 200 pounds; acid phosphate, 350 pounds; potassium sulphate, 100 pounds.....	236,000	Pounds. 13,387.5
2	Nitrate of soda, 200 pounds; potassium sulphate, 100 pounds.....	213,400	10,587.5
3	Nitrate of soda, 200 pounds; acid phosphate, 350 pounds.....	314,000	15,425
4	Acid phosphate, 350 pounds; potassium sulphate, 100 pounds.....	352,400	15,787.5
5	No fertilizer.....	221,600	9,750

These data bear out former statements in regard to the benefit to be derived from fertilizers, but also show that more systematic tests are necessary to determine the best combination as well as the amount of fertilizers to be used.

Radishes.—An experiment having for its object a determination of the effect of time of application of nitrate of soda to radishes has been running for some time. All plats have been treated with 320 pounds of acid phosphate, 160 pounds potassium sulphate, and 200 pounds nitrate of soda, the nitrate of soda being applied to plat No. 2 before planting; plat No. 3, one-half at planting time and one-half two weeks later; plat No. 4, one-third at planting time, one-third one week later, and one-third two weeks after planting; and plat No. 5, one-fourth at planting time, one-fourth one week after planting, one-fourth two weeks after planting, and one-fourth three weeks after planting. Plat No. 1 was used as a check. The results of five of these tests are summarized in the table following.

Effect of time of application of nitrate of soda on yield and quality of radishes.

Test No.	Date of planting.	Plat No. 1.		Plat No. 2.		Plat No. 3.	
		Yield per acre.	Quality of yield.	Yield per acre.	Quality of yield.	Yield per acre.	Quality of yield.
		<i>Pounds.</i>		<i>Pounds.</i>		<i>Pounds.</i>	
1	Aug. 4.....	1,843	Fair.....	2,775	Excellent...	2,131	Fair.
2	Sept. 9.....	1,450	Good.....	2,550	Very good...	2,218	Good.
3	Oct. 10.....	787	Poor.....	4,281	.....do.....	3,443	Very good.
4	Nov. 27.....	750	.....do.....	2,200	.....do.....	2,518	Good.
5	Mar. 26.....	650	Fair.....	1,750	Fair.....	900	Fair.
	Total yield.....	5,481	.....	13,556	.....	11,212	.....

Test No.	Date of plating.	Plat No. 4.		Plat No. 5.	
		Yield per acre.	Quality of yield.	Yield per acre.	Quality of yield.
		<i>Pounds.</i>		<i>Pounds.</i>	
1	Aug. 4.....	2,762	Fair.....	1,806	Fair.
2	Sept. 9.....	2,456	Very good...	2,712	Good.
3	Oct. 10.....	3,706	.....do.....	2,637	Very good.
4	Nov. 27.....	2,047	.....do.....	2,875	Do.
5	Mar. 26.....	1,187	Fair.....	1,187	Fair.
	Total yield.....	12,156	.....	11,218	.....

Through an oversight phosphate and potash were not added to plat No. 1 in any of the tests, but in the next year's work an additional plat will be added, to which these will be applied. Plat No. 2 shows an increase in yield of 11 per cent (1,400 pounds) over the next highest yielding plat. Both for production and quality it was found most profitable to apply the full amount of nitrate of soda just before planting.

Tomatoes.—Poor results have followed the various attempts to grow tomatoes from imported seed, principally because the fruit fails to set on the vine. The native tomato is very small, but is prolific and palatable, and work has been started in improving this variety by crossing native on American varieties and vice versa, by grafting, and by selection.

LONGEVITY OF VEGETABLE SEEDS.

It has been noted that seeds rapidly lose their viability in Guam. As stated in the 1916 report, an experiment was started to determine the longevity of various vegetable seeds under different conditions of storage, two methods being used. In one case the seeds were stored in ground-glass top exhibition jars and in the other they were put in cloth sacks and placed in insect-proof wooden cabinet drawers. Duplicate sets of seeds were used in each germination test, 100 seeds (40 of the beans) being placed between sheets of blotting paper, which were kept moist between two plates, one inverted over the other. The following table gives the results obtained from two tests,

requiring nearly two years for completion. The first test was begun August 1, 1915, and was completed March 15, 1917; the second was started September 1, 1916, and was completed the following June.

Comparative percentages of germination of vegetable seeds stored in jars and sacks.

FIRST TEST.

Date of test.	Carrot.		Pepper.		Water-melon.		Cucum-ber.		Okra.		Radish.		Wax beans.		Lima beans.	
	Jars.	Sacks.	Jars.	Sacks.	Jars.	Sacks.	Jars.	Sacks.	Jars.	Sacks.	Jars.	Sacks.	Jars.	Sacks.	Jars.	Sacks.
Aug. 1.....	57	60	70	63	74	71	95	94	83	95	100	100	100	100	100	100
Sept. 1.....	57	41	52	57	77	81	96	93	91	92	94	94	98	98	98	98
Sept. 15.....	47	31	39	44	77	82	91	96	80	79	94	93	98	98	98	98
Oct. 1.....	46	34	34	21	85	81	94	94	88	80	95	95	98	90	98	95
Oct. 15.....	46	32	38	36	84	63	88	78	87	73	93	90	93	80	98	98
Nov. 1.....	51	19	15	8	64	70	92	91	92	90	95	93	98	98	98	95
Nov. 15.....	33	7	27	4	78	60	92	63	83	71	93	93	98	45	100	88
Dec. 1.....	32	10	27	12	57	62	86	54	84	71	89	73	95	0	98	75
Dec. 15.....	38	0	20	0	55	57	71	19	87	60	95	70	95	0	98	78
Jan. 1.....	31	0	16	0	38	32	81	17	84	46	86	47	68	0	98	55
Jan. 15.....	16	0	15	0	39	26	66	36	74	22	87	35	83	(1)	98	48
Feb. 1.....	27	(1)	18	(1)	41	30	66	8	79	45	82	25	80	.....	93	28
Feb. 15.....	36	.....	17	.....	55	34	57	2	70	18	89	30	75	.....	95	8
Mar. 1.....	19	.....	12	.....	32	26	54	4	74	22	88	17	88	.....	95	.....
Mar. 15.....	21	.....	0	.....	38	25	39	0	72	24	90	19	70	.....	93	.....
Apr. 1.....	11	.....	3	.....	38	26	54	5	74	2	86	17	60	.....	93	.....
Apr. 15.....	6	.....	0	.....	55	39	43	0	76	26	94	27	75	.....	85	(1)
May 1.....	19	.....	0	.....	32	7	23	0	59	22	91	23	53	.....	85	.....
May 15.....	25	.....	0	.....	36	15	18	0	80	17	76	0	38	.....	90	.....
June 1.....	8	.....	(1)	.....	25	6	12	(1)	65	0	68	0	53	.....	88	.....
June 15.....	0	.....	.....	.....	36	2	8	.....	58	0	47	0	30	.....	75	.....
July 1.....	(1)	.....	.....	.....	17	0	0	.....	64	0	77	(1)	0	.....	80	.....
July 15.....	.....	.....	.....	.....	16	0	0	.....	58	0	65	.....	0	.....	84	.....
Aug. 1.....	.....	.....	.....	.....	17	0	0	.....	46	(1)	64	.....	(1)	.....	65	.....
Aug. 15.....	.....	.....	.....	.....	0	0	0	.....	72	.....	75	.....	.....	.....	82	.....
Sept. 1.....	.....	.....	.....	.....	(1)	(1)	(1)	.....	48	.....	45	.....	.....	.....	54	.....
Sept. 15.....	.....	.....	.....	.....	.....	.....	.....	.....	30	.....	13	.....	.....	.....	29	.....
Oct. 1.....	.....	.....	.....	.....	.....	.....	.....	.....	22	.....	20	.....	.....	.....	37	.....
Oct. 15.....	.....	.....	.....	.....	.....	.....	.....	.....	37	.....	32	.....	.....	.....	47	.....
Nov. 1.....	.....	.....	.....	.....	.....	.....	.....	.....	43	.....	50	.....	.....	.....	39	.....
Dec. 1.....	.....	.....	.....	.....	.....	.....	.....	.....	35	.....	30	.....	.....	.....	46	.....
Dec. 15.....	.....	.....	.....	.....	.....	.....	.....	.....	30	.....	0	.....	.....	.....	48	.....
Jan. 1.....	.....	.....	.....	.....	.....	.....	.....	.....	47	.....	59	.....	.....	.....	0	.....
Jan. 15.....	.....	.....	.....	.....	.....	.....	.....	.....	5	.....	3	.....	.....	.....	0	.....
Feb. 1.....	.....	.....	.....	.....	.....	.....	.....	.....	0	.....	6	.....	.....	.....	0	.....
Mar. 1.....	.....	.....	.....	.....	.....	.....	.....	.....	0	.....	0	.....	.....	.....	0	.....
Mar. 15.....	.....	.....	.....	.....	.....	.....	.....	.....	(1)	.....	(1)	.....	.....	.....	(1)	.....

SECOND TEST.

Sept. 1.....	68	64	8	0	82	84	98	99	95	97	99	98	93	95	99	98
Sept. 15.....	76	79	0	0	89	86	96	92	94	91	98	98	91	93	92	89
Oct. 1.....	66	59	0	5	82	79	87	89	95	94	95	95	89	90	95	96
Oct. 15.....	65	60	1	0	81	83	92	87	98	94	94	93	84	84	96	96
Nov. 11.....	63	55	0	0	80	81	89	87	93	89	95	93	88	86	93	80
Dec. 1.....	18	50	0	0	77	63	96	98	94	93	90	78	74	75	80	77
Dec. 15.....	86	89	0	0	91	91	79	91	83	86	96	90	80	45	59	38
Jan. 1.....	62	63	0	4	64	44	61	36	78	82	93	79	53	46	89	76
Jan. 15.....	71	34	0	0	68	38	93	66	92	89	93	90	36	0	93	79
Feb. 1.....	92	85	0	0	76	69	60	57	89	78	97	87	35	0	91	70
Feb. 15.....	66	40	0	2	79	9	68	43	87	66	64	61	19	0	84	36
Mar. 1.....	65	54	0	0	88	74	84	42	96	92	98	90	42	29	87	82
Mar. 15.....	7	3	0	0	49	22	41	4	92	82	38	59	17	0	89	56
Apr. 1.....	7	0	0	0	40	15	34	2	85	56	39	13	3	0	73	39
Apr. 15.....	5	6	0	0	34	41	39	39	34	41	0	0	0	0	3	4
May 1.....	6	6	0	0	33	36	32	36	23	44	7	10	0	0	7	5
May 15.....	0	0	0	0	59	57	0	0	33	19	0	0	0	0	0	0
June 1.....	0	0	0	0	33	23	0	0	15	13	0	0	0	0	0	0

¹Test discontinued.



FIG. 2.—INARCHED GUAM-SAIPAN MANGO TREE.



FIG. 1.—SAIPAN MANGO TREE.

The following table gives the number of days from the beginning of the tests to the time when none of the seed were viable, as shown by several additional germination tests. It would appear from this experiment that for seed storage purposes, glass jars are preferable to sacks kept in wooden drawers. It also appears that neither method will keep the seed in good condition for an entire year if the containers are opened at frequent intervals, as in taking samples for germination in the above trials.

Number of days from date of starting germination test to date of complete absence of viability.

Seed tested.	Test No. 1.		Test No. 2.		Average.	
	Jars.	Sacks.	Jars.	Sacks.	Jars.	Sacks.
Carrot.....	319	122	257	257	288.0	189.5
Pepper.....	228	137	75	137	151.5	137.0
Watermelon.....	380	334	300	300	340.0	317.0
Cucumber.....	334	227	257	257	295.5	242.0
Okra.....	549	304	300	300	424.5	302.0
Radish.....	564	319	257	257	410.5	278.0
Wax bean.....	365	122	227	196	296.0	159.0
Lima bean.....	518	212	257	257	387.5	234.5

FRUITS.

Papayas.—The station orchard of Hawaiian and Madagascar papayas is just coming into bearing. The trees have been fertilized with chicken manure, and interesting results are expected.

It is the common impression that Hawaiian papayas from seed of Guam-grown fruit are inferior to those grown from imported seed. Such does not appear to be the case in the one instance in which a systematic test has been carried on in this direction. The island government gardens contain trees from the F₂ generation of Guam-grown seed, bearing fruit of good size, deep, rich orange color, and “fruity” flavor. Seed of the F₃ generation is being planted to see whether the fruit will continue to be of as good size and quality.

An experiment is under way in grafting or inarching the Hawaiian and Madagascar varieties on the native papaya stock. Papayas grow wild all over the island, but the fruits are very small and inferior to those of the Hawaiian or Madagascar varieties. However, they are very hardy and withstand heavy winds that are prevalent at certain seasons of the year. It is desired to combine these qualities with the desirable characteristics of the imported varieties.

Bananas.—Work with bananas was started at the station in 1911 and 1912. Several promising varieties were imported and propagated, and a large number of plants distributed. Apparently very little has been done with the project during the past few years, and at present the station plantation contains only a few native varieties. The banana is one of the main food crops of the island and a few

plants are found growing around nearly every house. The native varieties are all inferior to the imported ones. In view of the existing conditions and the demand for plants of improved varieties, an effort is being made to develop this work.

During the year a cooperative fertilizer experiment was started with the industrial department of the naval government of Guam. Lacatan banana suckers from the Philippines were set out January 5, 1917, on the Barrigada farm. These have made a good growth during the summer months and are in good condition for the rainy season. Jack beans and velvet beans as cover crops and pigeon peas for windbreaks will be planted in this orchard.

Mangoes.—Mention was made in last year's report of the light yields of the seven large Guam mango trees at the station. During the fiscal year three of these produced several hundred fruits each, in each case the fruit being borne only on the side of the tree which had the most new growth.

Mangoes always command a good price, and the demand on the home market is greater than the supply. Land is often valued by the natives according to the number of mango trees growing upon it. Postmaster J. H. Underwood, of this place, says that one tree on his ranch produced during the last season 3,500 marketable fruits, which sold from 5 to 15 cents each. It is therefore not difficult to see why the trees are so highly prized.

During June, 1917, a variety called Peters No. 1 and supposed to be one of the famous Bombay mangoes, which was transplanted at the station in September, 1913, matured three fruits of medium size and a very rich red color, but extremely fibrous and with a decided turpentine flavor. Other varieties in this test have not yet fruited. Plate V, figure 1 shows a Saipan mango which has been inarched on a Saipan stock. It is four years old and produced a crop of fruit during the past year. Plate V, figure 2 shows an inarched Guam-Saipan mango which is nearly three years old.

Both the mango tree and its fruit are almost entirely free from serious pests. The Mediterranean fruit fly is not present on this island, and with rigid inspection of importations of fruit, the mango is likely to continue free from pests and to be the most highly esteemed fruit on the island. Efforts are being made to induce the planting of more trees.

Avocados.—During the year the avocado (commonly called alligator pear) trees at the station bore fruit for the first time. The avocado, introduced since the American occupation, fruited on the island for the first time in 1909. It has been said that fruits produced in Guam are equal if not superior to those grown in the Hawaiian Islands. The avocado seems to be admirably suited to both

soil and climatic conditions of Guam and is already widely spread over the island. Several hundred trees were set out during the past year. The fruit is greatly relished as a salad by most Americans, and so far there has been a ready market for all that has been offered for sale. The tree is sometimes attacked by a borer, but otherwise it is apparently free from insects.

Oranges.—Improvement work with oranges was started some time ago through the introduction of foreign varieties, many of which have died because of disease and unsuitable soil conditions. Some of the trees have already borne fruit, which appeared, however, to be inferior to some of the native varieties of oranges, being more or less coarse and sometimes developing astringency. Among the oranges commonly spoken of as native but probably introduced from the Philippines several generations ago, the two which are preferred to all others are those called by the natives “cahet” and “naranjita.” The rind of neither of these colors perfectly but becomes a light green when ripe. The pulp of the cahet is a rich golden color, while that of the naranjita is generally blood red. Both fruits are very juicy and fairly sweet. The seeds run from none at all to a great many in each fruit. From recent results, it would seem that improvement could be brought about by selection and by budding the superior seedless varieties on the native stock rather than by introducing new varieties. However, both means will be tried until the more practical has been demonstrated.

Lemons.—Lemons grow practically in a wild state on the island, good-sized fruit selling on the market from 3 to 5 cents a dozen. A strain of native lemon, now being used for selection work, is giving promising results, as the fruit is large, juicy, fairly smooth, and of excellent flavor.

Trees of the Villa Franca, Lisbon, and Eureka varieties have been introduced but have not yet borne fruit. The large number of seedlings now planted in the nursery will be budded when large enough with the varieties that have proved the most promising.

ECONOMIC PLANTS.

COCONUTS.

As mentioned in last year's annual report, an experiment was begun to test the effect of cultivation and intercropping on coconuts. This test, unfortunately, was started in a poorly drained and otherwise unsuitable location. During the rainy season so many of the seedlings died that it was necessary to discontinue the experiment.

Copra, the product of the coconut, continues to be the leading export from Guam. In view of the importance of this crop and the

careless cultivation or entire lack of it found in the groves owned by the natives, the station has again started experiments to determine the effect of cultivation, intercropping, distance of planting, and use of fertilizers on the young trees. A planting was made in February at the Cotot stock farm, conclusive results from which will not be available for several years, but already the effect of fertilizers is evident in the increased vigor and size of the treated trees.

Recent reports have been received of the presence of a very serious coconut disease which is ravaging whole areas and completely destroying many trees on neighboring islands. Precautions have been taken to prevent the introduction of the disease through importations.

A just criticism of the native farmer is that he plants his trees too close for the production of good nuts. It is common to see trees so close together that their growth is abnormal, the leaves forming a narrow fan instead of a natural hemispherical crown. Trees showing the former growth are never as heavy bearers as those having sufficient room to develop in a normal manner. However, trees planted for leaf production should not be confused with those planted solely for their nuts.

P. Nelson, an American plantation owner now on the experiment station staff, who has been on the island since the American occupation and thus has had a chance to observe different methods, says that 30 feet each way is the shortest distance apart that coconut trees should be planted. This distance gives 48 trees to the acre. From his observations and his experience with a bearing grove of 25 acres, Mr. Nelson gives the following as his idea of a better method for permanent plantations:

The trees should be planted 40 feet apart each way, and various cultivated crops raised between the trees for several years. After these trees have been in bearing for about 10 years, young trees should be planted in the center of the square made by each 4 trees, thus giving 54 trees to an acre. By the time the older trees begin to decline the younger ones will have come into bearing so that there will be no loss between the time of the two plantings.

This plan would make for the largest yields from the smallest area of land, give each tree a maximum space for development while bearing its first nuts, provide the sanitary conditions so important to the health of the plant, and secure returns from cultivated crops before the first trees come into bearing.

CACAO.

Cacao grown on the island is of high quality and the home demand at present is larger than the supply. At one time there was considerable cacao grown on the island, but during 1900 a severe

typhoon destroyed or badly damaged nearly all the plantations, and they have never been reestablished to any extent. It would seem that interest could be revived and a profitable industry started.

Cacao is better adapted for export than almost any other crop grown on the island. In proportion to money value it is less bulky than other crops and will stand storage for long periods, an important consideration where transportation facilities are limited and markets distant.

Work on the cacao project has not been definitely started. At present there are about 20 small trees on the station farm and these are being used for preliminary study.

COFFEE.

During the time of Spanish rule, coffee was planted on a considerable area in Guam, but production has declined, evidently due to lack of interest on the part of the natives and to lack of encouragement from the Americans. The crop now occupies a very small part of the tillable land of the island, the largest plantings at the present being found near the village of Sinajana.

The quality of Guam coffee is said to be far superior to that of any imported brand, and several coffee companies have offered fair prices for the product produced in quantities sufficient to attract suitable transportation. The climate and much of the soil are well adapted for the growing of the crop. Shade may be furnished by a number of plants common to the island, and if necessary, temporary wind-breaks may be established by planting pigeon peas and permanent ones of camachile (*Pithecolobium dulce*), lemons, or mangoes. No systematic work has been started at the station under this project, but it is planned to begin a variety, shading, and fertilizing test as soon as it can be arranged.

STARCH-YIELDING PLANTS.

Many plants growing on the island yield starch, and these are grown or used almost entirely for their starch, although some of them are valuable in other ways. While it is a common practice for the natives to make starch, there is no modern machinery for extracting it, nor is its manufacture conducted as a commercial enterprise. Each family extracts the starch by some crude method, generally by mashing the starch-yielding part of the plant with stones or by grinding with a pestle in a wooden or rock mortar. The material is then placed in water, which allows the starch to settle out, after which it is drained and then thoroughly dried in the sun. With the bitter varieties of plants it is customary to pass the starch through several

changes of water to remove the disagreeable and sometimes poisonous elements. A list of the starch-yielding plants of Guam is given below:

*Starch-yielding plants of Guam.*¹

Scientific name.	Chamorro name.	Common name.
<i>Alocasia indica</i> and <i>A. macrorrhiza</i>	Piga.....	Acrid taro.
<i>Artocarpus communis</i>	Lemae and dugdug.....	Breadfruit.
<i>Cacara erosa</i>	Hikamas.....	Yam bean.
<i>Caladium colocasia</i>	Suni.....	Taro.
<i>Canna indica</i>	Maño halom-tano.....	Canna.
<i>Cycas circinalis</i>	Federico or fadang.....	East Indian cycas.
<i>Dioscorea</i> spp.....	Dago, nika, gado.....	Yams.
<i>Ipomœa batatas</i>	Kamote.....	Sweet potatoes.
<i>Manihot manihot</i>	Mandiuka.....	Cassava or tapioca.
<i>Maranta arundinacea</i>	Aroru.....	Arrowroot.
<i>Musa paradisiaca</i>	Chotda.....	Bananas and plantains.
<i>Oryza sativa</i>	Fai or palai.....	Rice.
<i>Tacca pinnatifida</i>	Gabgab or gaogao.....	Polynesian arrowroot.
<i>Zea mays</i>	Maeis.....	Maize or Indian corn.

¹ Safford, W. E. Useful Plants of Guam. U. S. Nat. Mus., Contrib. Nat. Herbarium, 9 (1905), pp. 376, 377.

Arrowroot.—Among the most commonly used starch plants of Guam are the two arrowroots, the gabgab, or Polynesian, and the aroru, or common, arrowroot, both of which grow wild on the island. The former is preferable, as it makes a white starch, but the supply is generally insufficient to meet the demand, as the amount growing in a wild state in the woods is not great. The aroru is much used but does not make so white a starch as the gabgab. It is generally cultivated in close proximity to the houses so as to be readily accessible for making starch or sweetmeats from the edible tubers. The arrowroots are propagated from small tubers or root tips with eyes like those of the ordinary Irish potato. The leaves resemble those of the canna but are smaller.

Cassava.—This plant, which is found growing in most of the native gardens sometimes to a height of 10 feet, has fleshy tuberous roots used for making meal, starch, and cassava, or tapioca, flour. It may also be used in the fresh state as a stock food. Because of its easy cultivation and ready propagation by cuttings, the cassava probably furnishes a larger percentage of the starch used in Guam than any other cultivated plant. Both the sweet and the bitter sorts are admirably suited to the climate of the island and produce heavy root crops. The plant would repay more extensive cultivation, especially for flour production, in view of the present price of wheat.

Cycas.—This plant has a very beautiful palmlike trunk crowned with stiff fernlike leaves and bearing nuts called federico or fadang. The plant grows wild throughout the island especially in rough rocky places. The nuts are poisonous until they have been soaked for several hours in successive changes of water. Starch made from the nuts is used as food by a great many of the natives. It is of a very high quality but has a disagreeable odor. The cycads have

played an important part in the life of the people of the island. Hurricanes or typhoons have at times destroyed large quantities of food, after which the people have gathered federico nuts and lived largely on them until other food became available.

BAY TREE (PIMENTA ACRIS).

This plant has been introduced only recently by the station but the leaves are already being manufactured into bay-rum in considerable quantities by the Susana Pharmacy, Agana. The quality of the product seems to compare favorably with any of the bay-rum on the market. It would appear that Pimenta offers a good opportunity for starting an export trade, as the plant thrives well, producing an abundance of leaves.

CAMPHOR.¹

The camphor trees introduced during 1911 have remained healthy, and although only about 7 feet in height, they give promise of reaching a good size.

RUBBER.

A few trees each of the true India rubber (*Ficus elastica*), Ceara rubber (*Manihot glazovii*), and Para rubber (*Hevea brasiliensis*) are on the station grounds. While they have not become large trees as yet, they appear to be well adapted to Guam conditions.

PALMS.

Among the ornamental plants growing at the station which are suited to Guam conditions should first be mentioned the introduced palms. The royal palms (*Oreodoxa regia*) are the most showy, as they are tall and stately, those in the office grounds, although only six years old, having already attained an average height of over 40 feet. Near the close of the year the naval government transplanted from the station nursery a number of these palms from 2 to 4 years old. The plant is strongly recommended for beautifying drives and yards, as it grows exceptionally well and is not attacked by any serious insect or disease.

The fish-tail palm (*Caryota urens*) is a rapid grower and its peculiar-shaped leaves make it a very beautiful plant.

An ivory nut palm (*Cælococcus amicarum*) introduced from the Caroline Islands has long pinnate leaves, with the lower half of the midrib bare of leaflets but with spiny bracts at regular intervals in place of the leaflets, which are broader and longer than those of either the coconut or royal palm. This palm takes its name from the

¹ Introduced as *Cinnamomum camphora* from Japan, but given by Bailey as *Camphora officinalis*.

fruit, a nut of ivory-like texture that has been exported from Guam in small quantities for use in making vegetable-ivory buttons.

The African oil palm (*Elaeis guineensis*) is a graceful, low-growing palm with many long, drooping leaves and lustrous black fruits growing in large clumps. It is the famous oil palm of the Guinea coast.

The Chinese betel nut (*Areca* sp.) when small makes one of the prettiest ornamental plants. It has a heavy cluster of short, double-curved leaves at its apex, with a bunch of bright red nuts just below the leaves. It is much more ornamental than its native relative, the common betel nut (*Areca catechu*), which is found in the low forest areas of the island.

The Panama hat palm (*Carludovica palmata*) is a stemless plant growing from root divisions as a cluster of leaves on smooth round petioles from 4 to 8 feet long. There is only one of these plants on the island, but judging from the growth of this, the palm is well adapted to local conditions.

The hemp palm (*Chamærops excelsa*), a rather dwarf plant with small fan-shaped leaves, grows slowly but is adapted to planting in small yards or in pots.

A number of plants of *Oreodoxa oleracea* are growing in the plant house, together with fan palms (*Latania borbonica* and *Washingtonia robusta*), but none of these can be recommended for planting, as they have not yet been given a thorough trial.

There are many other palms growing on the island, but the above are the only ones introduced by the station. All varieties, however, seem to do well under Guam conditions.

NURSERY.

The station nursery at the present time consists of over 2,000 trees and shrubs, of which about one-half are fruit, shade, and economic trees. The fruit trees are chiefly lemons, oranges, mangoes, and avocados, many of which will be budded or inarched during the coming year. Some of these will be kept for the station orchard, while the others will be distributed to interested farmers. The shrubs are mostly hibiscus, crepe myrtle, *Tabernæmontana*, and a few *Bougainvilleas*, all of which are greatly in demand. There are also several thousand cuttings of the hedge plant (*Barleria cristata*) available for distribution that are not included in the nursery.

REPORT ON THE PLANT DISEASE SITUATION IN GUAM.

By WM. H. WESTON, Jr., *Pathologist, Office of Cereal Investigations, Bureau of Plant Industry.*

INTRODUCTION.

Through the cooperation of the Bureau of Plant Industry and the Division of Insular Experiment Stations, United States Department of Agriculture, the writer was enabled to spend the month of March, 1918, in a survey of the plant disease situation on the island of Guam. While the time allowed to visit Guam was short, it was possible to gain some idea of the fungus diseases present on various crops and to estimate somewhat broadly their importance to agriculture either present or prospective.

THE DISEASE SITUATION IN MARCH, 1918.

In presenting the following notes on Guam plant diseases, the author apologizes for their scantiness. Much time was consumed in reaching the various representative agricultural regions, since the island, although small, affords inadequate facilities for transportation and comprises many parts inaccessible except on foot. Moreover, there was very little opportunity for culture work and none for extensive isolation and inoculation experiments. Although the weather was wet, it was none the less the dry season, and there was no such profusion of diseases, especially of the peronosporaceous type, as may be found during the rains. Nor was it the main season for crops. With corn, for instance, the "adventura" crop had been harvested, and the main rainy season crop was not yet planted. As it was necessary to collect material in whatever stage it was found and as there was no opportunity to return for more suitable specimens, the list of diseases here given comprises principally the more obvious and readily identified forms.

The identifications of the causal fungi were made by the author for the most part in Guam with the scanty literature available and with no mycologic herbarium for comparison. They must, therefore, be regarded as provisional, especially as regards the species. From the foregoing considerations, it is obvious that the list is in no way indicative of the pathogenic fungi of Guam, but serves only to give an idea of the diseases occurring on the crop plants of the island during the month of March, 1918. The diseases are presented according to host plants, those collected on other than crop plants not being included.

LIST OF DISEASES FOUND.

AVOCADO (*PERSEA AMERICANA*).

Leaf spot, anthracnose, due to *Colletotrichum glæosporioides*, occurring on a few trees in the governor's garden, Agana, but not serious at present, only occasional infested leaves and twigs being seen. A short time ago one tree was killed, however, by what was probably the same disease.

BANANA (*MUSA SAPIENTUM*).

Leaf spot, due to *Mycosphærella* sp., occurring generally throughout the whole island wherever bananas are grown, but generally serious only on the older leaves, especially those torn by wind or otherwise injured. The leaves, even though heavily infected, do not die for a long time. The disease was found to be most serious at Libugon. What was probably *Mycosphærella musæ* was found on some specimens, but generally the leaves lacked fungus fructifications, although mycelium was present. The fungus found is evidently causal, although in some cases it appeared to follow mechanical injury.

Anthracnose, due to *Glæosporium musarum*, occurring on cut stems and the skin of bruised fruits at the experiment station and at Yona. The disease is not serious, the fungus being evidently a wound parasite, which might possibly, however, be destructive on stored fruit. The specimen found on the stem and the one on the fruit skin were apparently identical. No comparison was made with type material of *G. musarum*, but the specimens agreed closely with the description given.

Stem rot, due to *Marasmius* sp., occurring on leaf sheaths at the base of the banana plant just above the ground, several cases being observed at Libugon. There was no indication that serious injury was caused, the fungus seeming rather to act as a wound parasite, since the stem showed only a local rotting area from which a few sporophores were produced. The fungus is probably *M. semiustus*, which is reported as causing a root disease. There was, however, no indication of the serious injury to the whole plant generally ascribed to this form.

BEANS (*PHASEOLUS* SP.).

Rust, due to *Uromyces appendiculatus*, occurring on native bean, jack bean, and Kentucky Wonder and other varieties, at the experiment station, Barrigada, Inarajan, and other places. The disease is serious on native beans as well as on introduced varieties, destroying a large amount of mature foliage and cutting down the vitality of the plants. It is interesting to note the occurrence of this fungus

on native beans. It is probable that, the fungus having been once introduced, the native variety proved less resistant and was subject to more serious injury than the introduced forms.

Anthracnose, due to *Colletotrichum lindemuthianum*, occurring at the experiment station and at Barrigada, but seemingly not a serious disease, since only a few spots on occasional pods were seen. Either the strains of anthracnose present are not very virulent or the conditions are unfavorable for their activity, since the injury caused was not nearly so serious as is often found in the States.

Leaf spot, due to *Cercospora* sp., occurring at the experiment station, Barrigada, Umatac, Inarajan, and other points. No serious injury was seen, though some leaves were lost in consequence of disease. More commonly the irregular spots enlarged and fell out, giving a shot-hole effect. The fungus is an interesting one, but it has not yet been determined whether it is *C. lussoniensis* of the Philippine Islands, or *C. cruenta* of North America and the West Indies.

Leaf miner (injury due to small pink larvæ). Although this is an insect trouble it demands mention because of its wide distribution over the island and its seriousness wherever encountered. The larva eats out the interior of the leaf, leaving only the thin, transparent upper epidermis above it. On some plants every leaf would be infested with one or more of these pests.

CABBAGE (BRASSICA OLERACEA).

Leaf spot, due to bacteria (?), found at Libugon and the experiment station, and seemingly causing considerable injury through the heavy loss of infected lower leaves. The spots, light brown in color, with darker, water-soaked areas in them, increase in size, sometimes falling out but more often persisting. The badly spotted leaves soon weaken and fall. Examination showed vast numbers of bacteria in the water-soaked areas in the spots in every specimen examined, and since no other causal organism was encountered, it is probable that the bacteria are responsible for the injury. The symptoms, however, are quite different from those of an attack by *Pseudomonas campestris*, since no blackening of the veins or general rotting of the plant occurs. Spores of *Cercospora* sp. were encountered, and septate hyphæ have in some cases invaded the spots, while a few pycnidia of an *Ascochyta* (probably *A. brassicæ*) were seen. These forms were rare, however, while the bacteria were always found in the spots.

CACAO (THEOBROMA CACAO).

This crop was formerly important, when a small quantity of cacao beans of very fine quality was produced on the island and consumed locally. The groves have never recovered from past typhoons, however, and now only a very few are to be found. One of the largest of

these is in the Yona region of the Pago River valley and belongs to the Basa ranch. The trees were not seen by the author, but they were reported to have been seriously injured by boring insects which tunneled the stems. Fullaway has mentioned a fungus disease on the leaves, but Mr. Basa had noticed no injury from this cause.

CITRUS VARIETIES (CITRUS SPP.).

Scab, due to *Cladosporium citri*, occurring on the leaves and occasionally also on the fruit of the native lemon at several points widely distributed over the island. Some damage was done, although the disease was not markedly injurious to the tree as a whole. Many leaves were so distorted as to cease functioning, while the appearance of the fruit was, of course, spoiled. The fungus seems quite generally to be carried by the leaf miner, for the tunnels of this insect (which commonly spoils the appearance of almost every tree) are followed by the characteristic corky elevations of the fungus infection.

A serious disease of branches and stems appears to be widely distributed throughout the island. It was seen on native lemon at Barrigada, Piti, Yona, and in the Cotot region. It is primarily a bark disease characterized first by the appearance of warty excrescences here and there, and later by the development of a general scaliness which finally results in the scaling off of the bark, girdling the branch or trunk, and death of the part of the tree above it. Insects seem to be involved in the trouble, as in many cases small larvæ were found under the warty outgrowths. Some fungi were found, which, however, seem saprophytic and secondary. After consultation with Doctor Reinking and Doctor Yates, of the Philippine Bureau of Science, it is believed that *Corticium salmonicolor* may be the cause, since the description of the effect this fungus has on citrus in the Philippines corresponds very closely to the symptoms seen in Guam.

Leaf spot, due to *Phyllosticta* sp. This disease was found in several places, but seems to be of negligible importance, as it appeared in very slight amount and seemingly did no damage to the tree beyond slightly spotting an occasional leaf.

COCONUT (COCOS NUCIFERA).

Leaf spot, due to *Pestalozzia palmarum*, occurring all over the island wherever coconuts are found. In general this disease only spoils the appearance of the trees by making the leaves spotted, ragged, and unsightly. The extent of the injury seems to vary greatly, the leaves of some trees being only slightly spotted, while others are heavily infected. At Libugon the disease was causing considerable damage to young palms, whose leaves were killed back from the tip, where all the leaflets were dead and torn, to the base, where a few leaflets still remained that were only slightly injured.

After this fungus had killed the tissue, other fungi commonly appeared around the edge of the spots and aided as wound parasites in the destruction of the leaf.

Gradual dying of the trees, cause unknown. This trouble appeared to be general throughout the island, and in any plantation an occasional infected tree could be found. At first this trouble seemed of minor importance, but the great number of cases encountered throughout the island produced an increasingly strong impression of its seriousness. The symptoms shown by this disease involve first the withering and hanging down of the lower leaves, followed gradually by others nearer the tip, until finally the whole top dies and the dead stub remains with a few dead leaves still hanging to it. The activity of the growing point is seemingly lessened sometime before the top begins to die, for in affected trees the diameter tapers with abnormal rapidity just below the top. In addition to the leaf symptoms it is generally found that the nuts show near the stem end dried brown patches, in which growth is checked and which cause the nuts to develop so irregularly as to become dwarfed and deformed and generally to fall when young. The progress of the disease is very gradual, but once the symptoms have appeared, ultimate destruction seems inevitable, as no trees were seen showing signs of recovery. It had been feared by those on the island that this trouble might be coconut bud rot, but fortunately it is not. Even at a distance it can be noted that the trees lack the distinctively loathsome odor of bud rot, also that the older and not the younger leaves droop first. Moreover, on cutting down an infected tree and examining the bud closely, no traces of bud rot were found. In the short period spent on the island it was not possible to determine the cause of this disease, but it presents some points of resemblance to one found by Petch in Ceylon caused by *Peronospora*. Its progress should be regarded with apprehension.

COFFEE (*COFFEA ARABICA*).

Leaf spot, due to an undetermined fungus, was found at Yona; but since only hyphæ were present on the specimens collected the cause could not be determined.

Coffee is grown quite generally throughout the island in scattered patches around the ranches, the most extensive culture being found at Sinajana, though bushes were also examined at Yona, Libugon, and Merizo. The crop gave the impression of being very healthy, except that some bushes were planted so close together as to cause a harmful shading of the lower branches. It is to be noted that no coffee rust (*Hemileia vastatrix*) was seen, and from conversation with the experiment station staff it would seem that this pest has

not yet appeared in Guam. The island is very fortunate in having so far escaped this widely distributed and extremely destructive disease of the Orient.

COTTON (*GOSSYPIMUM SP.*).

Angular leaf spot, due to *Pseudomonas malvacearum*, was found in all the cotton fields at the experiment station, where it had caused many leaves to fall, although the effect on the plant was not, on the whole, especially harmful.

Anthraxnose, due to *Colletotrichum gossypii*. A slight infestation was found in the patch northeast of the experiment station office, occurring principally on the bolls but resulting in very little damage to the field as a whole.

CUCUMBER (*CUCUMIS SATIVUS*).

Downy mildew, due to *Plasmopara cubensis*. At the experiment station, at Libugon, and at Barrigada, this disease was very noticeable. Its most serious damage was done at the experiment station, where almost all the plants were injured more or less and many were entirely destroyed. Although this disease has been found in the Orient and is well known throughout the United States and Europe, its occurrence in Guam is of considerable interest. At the present time no resistant mycelium or heavy-walled resting spores are known, and neither the thin-walled conidia nor the ordinary hyphæ seem capable of withstanding transportation on dry seed. It is, therefore, an interesting problem in plant disease distribution to explain just how this fungus reached such an isolated spot as Guam. Although supposedly the dry season, the rainfall was considerable in March, when this disease could be seen to spread with noticeable rapidity through the experiment station garden. It is highly probable that the prevalence and severity of downy mildew is responsible for the belief previously entertained that cucumbers could not be grown on the island. The disease appeared to be restricted to cucumbers in Guam, not occurring on the other cucurbitaceous hosts on which it has been recorded from other localities.

Powdery mildew, due to species of Erysiphaceæ. This disease was encountered in several widely separated localities over the island. Although its superficial nature renders it normally less destructive than downy mildew, still in many cases found the leaves were so heavily overgrown as to cause the ultimate death of the plant. It is of interest to note that *Capnodium* sp. was generally found more or less abundantly on leaves infected with powdery mildew.

EGGPLANT (*SOLANUM MELONGENA*).

Leaf spot, stem infection, and fruit rot, due to *Phyllosticta* sp. At Libugon and at the experiment station this disease was found to

be especially destructive. In the latter locality a plat of the New York Improved Large Purple variety was so seriously damaged as to prove almost worthless. When occurring on the leaves, the fungus was clearly referable to *Phyllosticta hortorum*, and so far as could be determined the fruit rot and stem infection were due to the same organism. No parasitism of the stem has ever been ascribed to this fungus, but in the case of the experiment station plants the infection appeared to begin at the tip of the stem and to progress downward, the injured areas showing a lighter colored bark with slightly wrinkled edges of the lesions. The few pycnidia appearing on the stem were quite similar in all characteristics to those on the leaf and fruit. It is a question whether this disease was introduced from the United States. Seed is imported each year from the Pacific Coast by the station, but the virulence of the disease, its infection of leaf, stem, and fruit, and its rapid destruction of the plant are not characteristic of its appearance in the United States. It is possible that a *Phyllosticta* parasitic on the common eggplant of Guam has transferred itself with disastrous effect to the more susceptible introduced variety.

MAIZE (ZEA MAYS).

Yellowing and dwarfing, due to unknown cause. Although the main corn season had not yet begun, small patches of corn were seen at the experiment station and at Libugon, Yigo, and Umatac, in all of which there were examples of yellowing, mottling, and striping with attendant deformation of the plant. This trouble did not appear nearly so destructive or extensive as in Hawaii, but in one field at Umatac it was causing considerable loss (Pl. VI, fig. 1.). From what has been seen in Hawaii, the progress of this disease should be watched with apprehension. In spite of careful examination, no casual organism was found. Conditions in Guam, as in Hawaii, seem to point to a physiologic or perhaps mosaic condition as the basis of the trouble. The leaves upon unfolding were striped, mottled, or marbled with yellow, the internodes were shortened, and the whole plant was somewhat dwarfed or deformed (Pl. VI, fig. 2.). In the worst cases the plants were barren, although seed of an inferior sort was borne by some. This trouble was ascribed to various causes by different people, but it appears to be the same baffling general condition observed in Hawaii rather than any specific disease.

Ear molds, due to *Fusarium* sp., *Aspergillus* sp., etc. The extreme humidity of Guam and the softness of the cob of corn produced there are very favorable to molding of corn on the stalk. The molds, however, are less destructive by themselves than they are as followers of the corn earworm. Acting together, these two agencies cause a spoilage of an appreciable amount of each crop.

WILD MELON (*CUCURBITA* SP.).

Powdery mildew, due to species of *Erysiphaceæ*. At Barrigada this disease was found infecting an extensive patch of wild native melon. Very little injury was being done the plants, as only the older leaves were spotted and very few of these were falling. Examination showed that only the imperfect stage of the fungus was present, a characteristic of all the powdery mildews of cucurbits collected in Guam. The occurrence of this disease on a wild melon is of interest, and it is possible that this host was the original source from which the disease was transmitted to various cultivated plants of close relationship.

MUSKMELON (*CUCUMIS* MELO).

Powdery mildew, due to species of *Erysiphaceæ*. Both at the experiment station and at Libugon, the muskmelon plants were found to be infected with this disease. Considerable damage was done, often half of the leaves being lost and at times the whole plant being destroyed. As mentioned above, only the conidial stage of the fungus was found. A species of *Capnodium* seemed to be quite generally associated with the powdery mildew on the leaves, but no injurious effect could be attributed to it.

NARANJILLA.

Bark cankers, due to *Botryodiplodia* sp. Only a few of these plants (introduced from South America, botanical name not known) were present at the experiment station. Two of these were dying, seemingly due to a *Botryodiplodia*, since the bark of the stems showed typical cankers and eventually sloughed off, while characteristic pycnidia of the fungus appeared in large numbers. Whether the fungus was truly parasitic, however, could only be established by inoculation, and the general sickly condition of the plants made it doubtful whether the *Botryodiplodia* was entirely responsible for their destruction. The fungus itself seemed to be a *Botryodiplodia* as described by Petch, but the species was not determined.

OKRA (*HIBISCUS* ESCULENTUS).

. Stem infection due to *Phoma okra*. This was found on occasional plants in the experiment station garden. The seriousness of the infection was slight, since only a few plants were diseased. These, however, lost their leaves, and in the stems which remained standing the discolored sunken areas produced innumerable pycnidia. The fungus probably was *Phoma okra*, although it resembled somewhat *P. malvacearum*. It can hardly be regarded as a dangerous parasite in Guam, since only plants whose vitality was declining became infected.



FIG. 1.—YELLOWING AND DWARFING OF MAIZE AT UMATAC.



FIG. 2.—EXCESSIVE YELLOWING AND DWARFING OF MAIZE, CAUSE UNKNOWN.



FIG. 1.—LEAF ROLLER INJURY TO RICE AT INARAJAN.



FIG. 2.—SORGHUM AT THE STATION IN POOR CONDITION, CAUSE UNKNOWN.

PAPAYA (*CARICA PAPAYA*).

Leaf spot, due to undetermined cause. Leaf spots were found on occasional papaya trees throughout the island. In all the specimens examined, however, no causal fungus was apparent. On placing some of the specimens in a damp chamber, a copious growth of *Diplodia* sp. was obtained on the spots. The fungus most closely resembled *D. caricae*, although it also showed points of similarity to *D. papayae*. There is very little reason to believe that it was the causal organism occasioning the leaf spots, however, since the pycnidia appeared on some specimens not only on the leaf spots but also on the petioles and midribs of the leaves.

PARSNIP (*PASTINACA SATIVA*).

Leaf spot, due to undetermined cause. In the experiment station garden many of the parsnip plants showed a spotting of the leaves at the tips, which became dark, leaving lighter centers and giving a general appearance of scorching. The trouble seemed serious, as every plant had some affected leaves, and many of these had fallen. In spite of repeated attempts, however, no fungus was found that could safely be considered causal. A *Phyllosticta* and several other secondary fungi were found, but the true cause was probably scorching or some other injury.

PEANUT (*ARACHIS HYPOGÆA*).

Leaf spot, due to *Cercospora* sp. In the government garden at Agana the peanut plants were found to be quite commonly spotted with this disease. Some leaves in all the hills were infected, a considerable loss of leaves apparently resulting. The spots were large, dark, and rounded, and the causal fungus appeared in all the specimens to be a *Cercospora*, probably *C. personata*.

Leaf spot, due to undetermined cause. This disease was found generally distributed through the same plat at Agana, where almost all the leaves showed more or less infection. The spots were small, brownish, and in some cases very numerous throughout the leaf, but in none of the specimens examined was any causal fungus found.

PEPINO.

This plant is one of the Cucurbitaceæ, and is thought to be a native cross.

Powdery mildew, due to species of Erysiphaceæ, was found at the experiment station, at Libugon, and at Merizo. It appeared to be very injurious, since a large proportion of the leaves were destroyed and sometimes the entire plant. Only the conidial stage of the fungus was found, and mixed with the thick powdery growth on the leaf surfaces were occasional dark patches of a *Capnodium*.

PUMPKIN (*CUCURBITA* SP.).

Powdery mildew, due to species of *Erysiphaceæ*. At Libugon and also at Barrigada, pumpkin plants were found to be infected with this disease. Its effect appeared to be very serious, since many of the leaves were dying, and even the whole plant had succumbed in some cases. The causal fungus, which formed a dense powdery growth over the surface of the leaves, was the conidial stage of some undetermined species of *Erysiphaceæ*.

PEPPER (*CAPSICUM* SPP.).

Leaf spot, due to *Cercospora* sp. On Cayenne pepper and sweet pimento pepper at the experiment station and on an unknown variety at Merizo, several specimens of this disease were found. The plants seemed to be attacked with varying degrees of severity, on some only the older, more shaded lower leaves being infected. Apparently the disease is not a very destructive or dangerous one. The fungus was clearly a *Cercospora*, but since several species of this fungus have been recorded as of little importance, no effort was made to determine the species.

Dying of stems, due to *Glæosporium* sp. In the experiment station garden there were a few plants the stems of which showed infected areas with which a *Glæosporium* was apparently associated as the causal organism. Only occasional cases of this infection were found, and it appears to be only mildly parasitic. The fungus may possibly be identical with *G. piperatum*, but since it is apparently restricted to the stems, the matter is in doubt.

Fruit rot, due to *Macrosporium* sp. This rot was found on small Cayenne peppers at the experiment station. In the few cases encountered, the fungus caused a darkening and rotting of the fruits when nearly ripe. Apparently the *Macrosporium* was chiefly destructive through following the tunneling of some insect.

Mosaic and leaf curl. (Due to physiological causes?) At several points on the island a few cases of these abnormal conditions were seen. They did not, however, appear to cause any appreciable damage.

RICE (*ORYZA SATIVA*).

The rice crop put in by the experiment station on the river bottom near Piti proved this year to be almost a failure, as a large percentage of the heads formed little if any grain. This condition was also noted at Merizo. It had been thought at the experiment station that this was due to insect injury, and this hypothesis was provisionally accepted, as no parasitic fungi could be found on the specimens collected. A comparison of the notes taken with the description of rice blast, however, indicates a strong resemblance between the Guam

disease and rice blast. Though no *Piricularia* was found in an identifiable condition, it is still possible that this fungus may have been the cause. If so, it will probably prove a serious disease to the island, and the matter certainly demands further study.

Insect troubles. Due to the attacks of a leaf roller, a large field of rice at Inarajan was practically ruined, nearly every plant being so affected as to cease making proper development (Pl. VII, fig. 1).

SORGHUM (*ANDROPOGON SORGHUM*).

Yellowing of the leaves, due to unknown cause. At the experiment station, a field of sorghum proved to be in poor condition (Pl. VII, fig. 2). The crop had been planted on land supposedly injured through the previous growth of "enefuk" (*Andropogon aciculatus*), which may have served to weaken the plants. In any case, yellowing and mottling of the leaves was fairly common, the infected plants being rather sickly, although none of them showed the shortening of the internodes which marks similar conditions in corn. Repeated examination failed to disclose any downy mildew organism or other fungus which might be suspected of being the cause.

Insect injuries due to a stem borer and a leaf roller were seen to cause serious losses in the same field showing the yellowing described above. Young seedlings 6 to 8 inches high were attacked by the borer, after which they withered and died, the borer working so effectively at the surface of the soil or just below it that the top of the plant pulled out easily, leaving a rotten core. The leaf roller, on the other hand, proved to be a larva which curled up the older leaves, eating them from the inside until they were finally seriously injured.

It is of interest to note that no rust was found on sorghum, even on the Darso variety which was most seriously damaged by this common disease in Honolulu.

SQUASH (*CUCURBITA* SP.).

Powdery mildew, due to species of *Erysiphaceæ*. At the experiment station, and at Libugon and Barrigada, this disease was encountered. It appeared on the whole to be about as serious as on melons, and as far as could be seen at the experiment station, summer bush scallops were more damaged than crooknecks. As in the other cases, only the conidial stage was found and *Capnodium* was also present.

SUGAR CANE (*SACCHARUM OFFICINARUM*).

Only a slight idea of the diseases of this crop could be gained. Small patches were examined near Merizo and near Tepungan, but no diseases of importance were seen, although occasional pale, sickly plants were found which resembled closely specimens in Honolulu

which were suffering from unfavorable soil conditions. As sugar cane is not grown to any great extent, not even so much as in former years, there was very little opportunity to study it pathologically.

SWEET POTATO OR CAMOTE (*IPOMŒA BATATAS*).

White rust, due to *Albugo* sp. At Umatac a small amount of this infection was found in an extremely flourishing field of camotes which had been grown by a native under the supervision of one of the patrolmen. Only slight damage was done. The fungus is probably *Albugo ipomœæ panduranae*, although no comparison was made with herbarium specimens.

It is of interest to note that on wild morning-glory (*Ipomœa congesta*) a similar infection with white rust was seen both at Piti and at Upi. This species was also commonly infected with a leaf spot due to *Cylindrosporium* sp. Most of the leaves were spotted but very little damage was done to the plant as a whole. The causal fungus is probably *C. bakeri*, which commonly causes a shot-hole effect on camote leaves in the Philippine Islands. Although occurring on a wild plant of no economic importance, this fungus is mentioned here because in all probability it will be found also on sweet potatoes (camotes) in Guam.

TARO OR SUNI (*COLOCASIA ESCULENTA*).

Leaf spot, due to *Glœosporium* sp. At Piti and Tepungan this disease was encountered on the commonly cultivated taro. Only occasional leaves were attacked, on which large spots lost their green color and became pale buff with occasional concentric markings. On the whole very little damage was done. The spots first attracted attention because they resembled those resulting from the attacks of *Phytophthora* on this host. A few cenocytic hyphæ were, indeed, found, but more generally *Glœosporium* was encountered. It was not possible to determine, however, whether this fungus is the causal organism or not. If *Phytophthora* is indeed involved it is probable that it would not have formed apparent conidiophores in the dry season, but in the wet season considerable loss might be expected.

TOBACCO (*NICOTIANA TABACUM*).

Leaf spot, due to *Cercospora* sp. This disease was encountered at Umatac and in the region near Cotot. In the latter region very little loss was occasioned, but at Umatac, where the plants were far too crowded, considerable damage was done to the lower leaves. Even though the leaves did not all fall off, the unsightly appearance caused by spotting rendered them useless for good grade tobacco. The causal fungus was a *Cercospora*, but there was no opportunity to determine definitely whether it was *C. nicotianæ* or *C. raciborskii*.

Mosaic, due to unknown cause. In both the regions mentioned above, a few cases were seen in which plants were obviously affected by mosaic, but fortunately these were very rare.

TOMATO (*LYCOPERSICUM ESCULENTUM*).

Leaf withering, due to *Cercospora* sp., was seen on tomatoes all over the island, not only on introduced varieties, but on the native tomato brought long ago from the Philippines to Guam where it is well established in almost every garden plot. The seriousness of the infection seems to depend somewhat on conditions, marked damage resulting only when the plants are crowded and are allowed to run on the ground. The disease produces irregular infected areas on the leaves beginning at the margin and working toward the midrib. On this area, which is not a sharply defined spot, a dark fuzz of conidiophores and spores appears. In the scanty literature at hand, no record was found of a *Cercospora* on tomato. Whether this will prove to be some well-known species or one hitherto undescribed remains to be determined.

TURNIP (*BRASSICA* SP.).

Leaf spot, due to bacteria, was encountered at the experiment station and resembles so closely that already described on cabbage that no further data need be given here, except that the trouble appeared more serious on turnip than on cabbage.

WATERMELON (*CITRULLUS VULGARIS*).

Powdery mildew, due to species of *Erysiphaceæ*. Both at Barrigada and at the experiment station plants were encountered infected by this disease. In general, however, the infection was only on the older leaves and was far less serious than on squash and on melon. As in the other cases mentioned, only the conidial stage was found.

Leaf withering, due to *Cercospora* sp., was seen at the experiment station, and in its general appearance closely resembles the similar trouble on tomatoes. The vines were somewhat damaged by the withering and dropping off of many of their leaves, but the disease can not be called especially destructive. The causal fungus was clearly a *Cercospora*, but no attempt has been made to determine whether the species is well known or new.

CONDITIONS IN GUAM FAVORING THE DEVELOPMENT OF PLANT DISEASES.

Of the broader aspects of the plant disease situation in Guam the preceding list can, of course, give little or no idea. On the whole, conditions in the island distinctly favor the development and increase of plant diseases. In the first place, the climate is moist and tropical,

enabling a wealth of fungi and insects to flourish unchecked by cold and extreme drought. Furthermore, the primitive agricultural practices markedly encourage the growth and increase of parasitic organisms, since the natives have no appreciation of the value of "clean-up" methods, and make no effort to destroy diseased material, to burn trash that may protect insects, or to eliminate volunteer plants that may harbor dangerous fungi. The quite general belief that the greater the number of plants in the field the greater the yield secured has resulted in the production of weakened plants and the development of diseases favored by overcrowding. As the native idea of rotation of crops is merely to let the soil rest when it is tired, no effort is made to combat diseases by rotation.

Besides these conditions favoring the development of diseases, Guam has for centuries been the recipient of unregulated importations of plants with their inevitable accompaniment of diseases. In the early days these introductions were principally from Mexico and the Philippines, with some few from the Caroline and other islands, while in recent years, the United States, Hawaii, and the Philippines have furnished a large proportion, with occasional introductions from Japan, India, and other more remote countries. The increasing number of diseases resulting have either found suitable conditions and become established or have persisted by adapting themselves to circumstances at first unsuitable for them. In spite of its shortness, the foregoing list nevertheless comprises fungi of both Orient and Occident, of tropical and temperate regions, and points seemingly to widely distributed sources for Guam's fungus flora.

Finally, the lack of a plant pathologist or entomologist has markedly favored the development of diseases on the island. During Spanish occupation no opposition was presented to inroads of plant diseases, and since the American occupation the available men and funds have been devoted almost wholly to pioneer work in agronomy and animal husbandry. This lack of definite work on disease control in the past has made more difficult the problem of disease control in the present and future.

CONTROL.

The disease situation in Guam although neither threatening nor critical at the present time, nevertheless presents a problem which sooner or later must be met. In the first place, the more serious diseases already present must be controlled and preventable losses cut down. This will require considerable experimentation with suitable sprays, with methods of sanitation adapted to conditions in Guam, with rotation of crops, and with resistant varieties. A determined effort will have to be made to educate the natives along these lines before the considerable losses now suffered can be reduced as they

should. There is also immediate need of extensive research on the special problems offered by some of the more serious diseases now active. In addition to the immediate problem of controlling the diseases already present on the island, the situation on Guam also demands the prevention of future introductions of plant diseases. In order to carry out the work of control, a specialist on plant diseases should be added to the station staff.

SPECIAL PROBLEMS OFFERED BY DISEASES NOW PRESENT.

Chief among these is the gradual dying of the coconut trees of which mention has been made. At first this was regarded as of little importance, but as it was encountered in various degrees of seriousness all over the island, it was recognized as taking considerable toll of this very important crop. In any fair-sized grove containing mature trees one or more examples will be found with drooping leaves and dwarfed, distorted nuts characteristic of this malady. As has been said, it has none of the symptoms of the much dreaded coconut bud rot, but in view of its resemblance to certain serious peronosporaceous diseases of coconuts in the Orient, it should be regarded with apprehension.

A coconut leaf scale has only recently wiped out all the coconut trees on Saipan. This island is the second largest of the Ladrões or Marianne group, and is only 120 miles from Guam. Constant trading goes on between the two. If this insect becomes established in Guam, coconut production will be ruined—a serious blow, as Guam's copra trade is its only profitable industry. The problem of eradication or of prevention of further spread of this pest well merits the immediate attention of an entomologist.

The corn crop also presents problems of considerable importance. The stem borer, earworm, and weevil, as well as the ear molds, are responsible for a heavy aggregate loss each year. Yet these are well-known maladies which have been kept in check in other places and which could be controlled in Guam if experiments were carried out to adapt known methods to the conditions there. Furthermore, the yellowing and dwarfing of corn found to be serious even in the few fields seen in the dry season is much more serious in the wet weather.

It is quite possible that extended inspection during the rainy season would reveal perhaps more serious diseases or pests at present unrecognized. In the case of rice, the destructive leaf roller needs attention, while the very heavy losses due to the failure of the heads to fill out demands immediate investigation. If, as seems probable, it should prove to be caused by *Piricularia*, considerable effort will be necessary to keep down the loss.

The control of the downy mildew of cucumber and the powdery mildews of various *Cucurbitaceæ* seems to present greater difficulties

than in the United States. Not only are they distinctly more destructive but also, in so far as could be learned from preliminary experiments made by the agronomist of the station, they are far more resistant to ordinary methods of control.

In addition to these pressing matters, there are many other opportunities offered the pathologist at Guam. During the rainy season with its innumerable attendant fungus diseases, the native plants related to cultivated crops harbor many fungi, and present a rich field for the pathologist interested in the original sources of important plant diseases, and as the flora of Guam is a conglomerate one from several sources, an incidental study of the fungi parasitic upon these forms would prove of great interest from the point of view of disease distribution.

PREVENTION OF FUTURE INTRODUCTIONS OF DISEASE.

Since Guam is a small island connected with other countries only by a few easily controlled traffic lines, the task of preventing the introduction of diseases should not be a difficult one. It is interesting to note that the phanerogamic flora of Guam has been largely introduced by man. According to Merrill, only 50 of the 280 pantropic species recognized from the island have been presumably brought there by natural causes such as ocean currents, while 314 of the total 550 species already known have been brought by man. It is probably justifiable to conclude that the fungus flora, especially the pathogenic forms, has in like manner been introduced through the agency of man. The prevention of the introduction of future plant parasites into Guam depends, therefore, on the control of plant importations.

Besides being included under some of the foreign quarantine orders of the Federal Horticultural Board of the United States Department of Agriculture, Guam is also under two executive general orders of the naval governor.¹ The first of these (No. 167, of July 21, 1911), a general order aimed solely at the exclusion of insect pests, reads in part as follows:

In order to prevent the introduction of insect pests into Guam the importation of all live plants, bulbs, tubers, cuttings, and of all other live parts of plants other than seeds is prohibited, except such as may be imported for food purposes, and except further that a limited number of useful plants may be introduced by the United States Department of Agriculture for use at the Government experimental farm. Plants for the experimental farm shall be imported only on a permit signed by the governor. * * * All plants thus introduced must be accompanied by certificate showing that they have been inspected and fumigated immediately prior to shipment. Upon arrival at Guam such plants must be fumigated and inspected.

¹ Guam Sta. Rpt. 1912, p. 26.

The second order (No. 168, of Aug. 24, 1911) is a more restricted one designed to prevent the importation of the Mediterranean fruit fly from Hawaii.

In spite of these precautions, however, the possibility of dangerous and costly disease introductions is by no means eliminated. Since 1911 the importations by the station, in addition to seeds from the United States, the Philippines, Hawaii, Ceylon, and other localities, have included also banana suckers with the necessary earth and wrappings to maintain them in proper condition, camphor and citrus seedlings from Japan in similar wrappings, and corn of 40 odd varieties from a wide range of distantly located tropical countries. The danger of bringing in citrus canker, corn mildew, or other serious diseases on such introductions is of course obvious.

At this point attention should be directed to the fact that there is grave danger of introducing into Guam from the United States a serious disease, the *Physoderma* of corn, which is distributed throughout the Southern States, but which is not, so far as observations indicate, present in Guam. The work of W. H. Tisdale and of the Plant Disease Survey of the United States Department of Agriculture has shown clearly that the disease is responsible for considerable loss in the southern part of the American corn belt. Should it ever gain a foothold in Guam, the favorable conditions, the entire dependence of the natives on their corn crop, and their inability to replace it if depleted, would combine to make the situation a very serious one. Every effort should be made to keep this disease out of Guam.

Emphasis should also be laid on the absolute necessity of taking no chances of introducing the *Hemileia* rust of coffee. The devastation wrought by this disease throughout the Orient is well known, and every precaution should be taken to avoid bringing such a disaster on Guam.

In like manner every endeavor should be made to prevent the introduction of coconut bud rot, a serious trouble in the oriental Tropics and in the West Indies which is not yet at work in Guam.

In all of the above cases, the local products are already of good quality and offer excellent material for improvement by selection; hence there is no need of endangering them by importing stock carrying possible infection.

The work of the Federal Horticultural Board has shown that inspection, no matter how careful, can not conclusively determine the potentialities for danger of an importation and has demonstrated beyond controversy the need of growing such importations in quarantine and providing for their supervision lest diseases develop. It is not desirable or necessary that plant introduction into Guam should cease, for this is a very important part of the experiment station

work, but these importations should be made under methods of procedure tending to reduce to a minimum the danger of bringing in undesirable parasites. The importation should be made from regions known, as far as possible, to be free from disease, should be inspected at the place of shipment and on arrival, if necessary, should be given fumigation or precautionary treatment. The growth of importations should be closely watched to insure speedy detection and extermination of any dormant diseases developing after inspection. In some cases it might perhaps be necessary to forego certain importations for the sake of safety, but this would at worst be very rare.

NEED OF A PATHOLOGIST AND ENTOMOLOGIST.

The foregoing account will serve to emphasize the need of a plant pathologist and entomologist in the agricultural development of Guam. It must not, however, be interpreted as a criticism of the work of the experiment station. The station has accomplished a great deal, how much no one can fully appreciate who has not actually seen the advances due to the efforts of the station staff, but the need of the disease situation is a specialized one which can only be met by the plant pathologist and entomologist. With the addition of such a specialist, the station would be enabled to accomplish even more, not only in cutting the present disease losses, but also in a broader way. As the station is the most southern and at the same time the most oriental one maintained by the United States Department of Agriculture, it is peculiarly suited to the study of diseases of tropical and subtropical economic plants, and the information gained at this station would be immediately important to Porto Rico, Florida, Louisiana, southern California, and similar regions of marked commercial importance.

It is, of course, understood that in the present great crisis efforts toward control and prevention of crop diseases should be concentrated on the United States, but nevertheless Guam does demand attention. The island belongs to the United States, and because of the cable, naval, and marine stations, the business interests concerned with the products of the island, and its increasing importance as a Pacific naval base, there is responsibility in its possession. Although the population of Guam is only a little over 10,000 and the island is quite capable of agricultural development far beyond the point of self-support, it is now importing both raw and prepared foodstuffs in relatively enormous quantities every year. There is undeniable need of continued agricultural development, and in this development the plant pathologist and entomologist will have ample opportunity to do a large share.

